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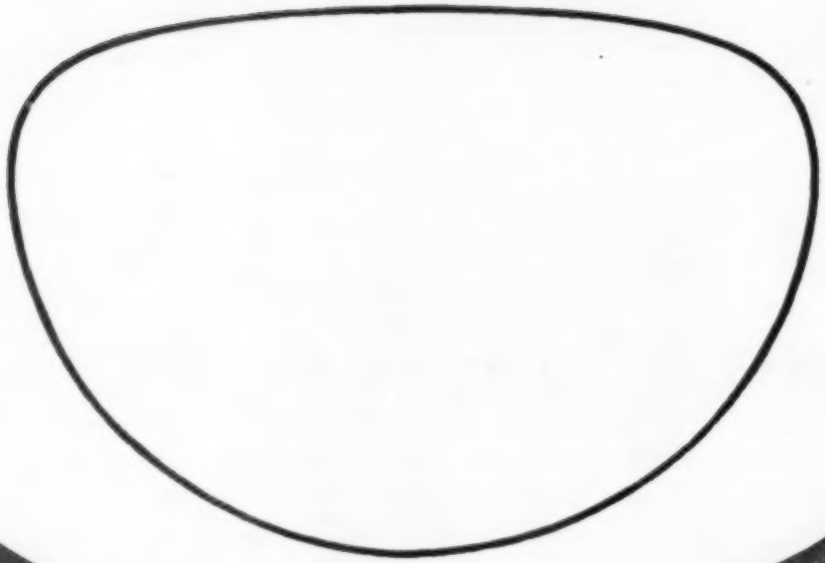

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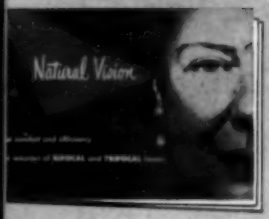

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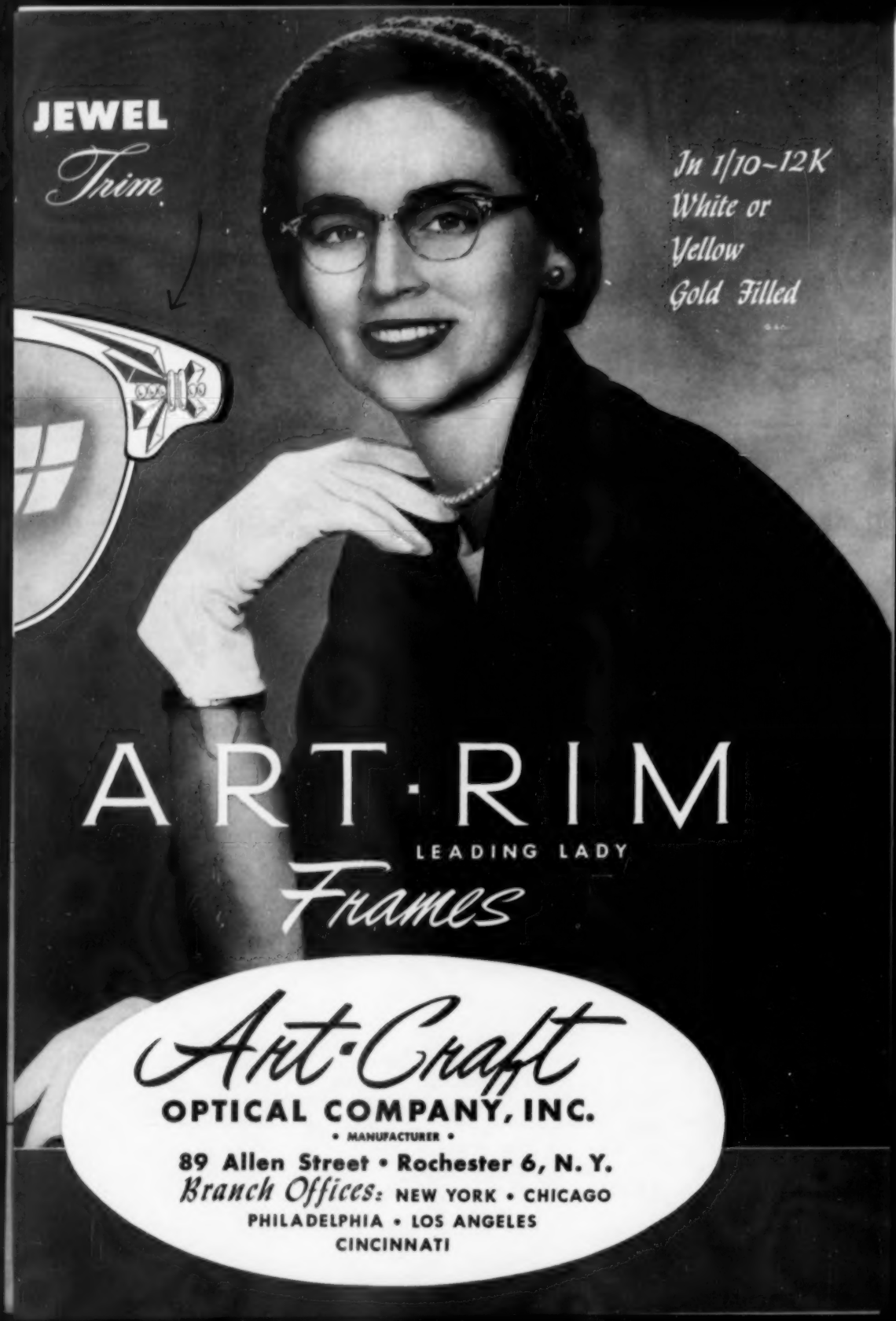
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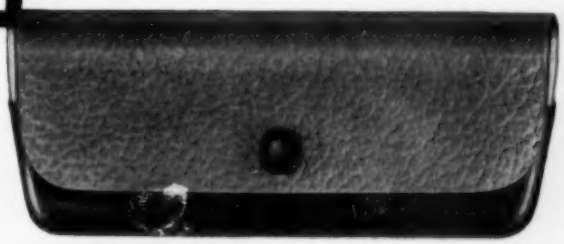

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LIGHT INTENSITIES PREFERRED FOR READING*

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The determination of illumination intensities suitable for effective and easy seeing while reading is a relatively important matter. Various criteria for ease of seeing have been employed from time to time. Casual consideration of the matter would seem to indicate that an individual should be able to select a level of illumination suitable for him to read comfortably and efficiently. As a matter of fact, a reader rarely hesitates to express a preference for what he considers to be an adequate light intensity for his visual needs. It is not surprising, therefore, that there has been some emphasis upon reader preferences in studying the relation between lighting and seeing. Certain investigators[1] consider results obtained by this method to be both interesting and significant.

Results in early investigations revealed considerable variation from one experiment to another. Under favorable conditions of light distribution and with general illumination of the room by gas-filled tungsten lamps, Luckiesh, Taylor, and Sinden[4] found that readers, on the average, preferred 5.3 footcandles for reading large type (11 and 12 point), and 10.6 to 16.1 for medium-sized type (9 point). For a low degree of brightness contrast between 9 point type and paper, 17.4 footcandles were chosen on the average when 30 were available. Apparently, the intensity selected depends somewhat upon the range of intensities available. Luckiesh and Taylor[3] had subjects select light intensities preferred for reading 9 point type under well-distributed incandescent illumination. With up to 8 footcandles available, the readers chose an average of 4.2; with up to 30 available, 10.6; with

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†Psychologist, Ph.D. Member of faculty.

up to 45 available, 16.1; with up to 65 available, 23.2; and with up to 100 available, 35.8. The authors inferred that the subjects did not choose the maximum because they probably assumed that the desired intensity was somewhere between the extremes. This conclusion appears to be erroneous. Visual adaptation seems to be playing an important role in the choices, as we shall see below.

In a more elaborate study, Luckiesh and Moss[1, 2] had each of 82 adult subjects select by actual trial the intensity of illumination they considered as ideal for reading black print on white paper for long periods. The preference was to be expressed solely in terms of their own criteria of comfort afforded by the lighting. The available illumination intensities were 10, 20, 50, 100, 200, 500 and 1000 footcandles. The average intensity chosen was 92 footcandles but the median was only 50. In a skewed distribution such as was obtained, the median is the more satisfactory measure of central tendency. In this and in the previous study, it is clear that the greater the range of light intensities available for exploration by the subject, the greater the intensity chosen as best for reading. It seems to the writer that the adaptation of the eye at the moment to an illumination level must influence to some degree the choice of an intensity for comfortable reading. If there is more light available, the eye would tend to be adapted for clear seeing at a brighter intensity level. However, in none of the studies cited was there any reference to visual adaptation or any attempt to control this factor. Inasmuch as preferences for light levels chosen for comfortable vision are considered important data in the science of seeing, there is need of further investigation to define more exactly the role played by visual adaptation in these choices. Only after such investigations have been performed will one be able to evaluate the validity of the method for prescribing illumination intensities for hygienic seeing.

In the present investigation a series of experiments were carried out in the Minnesota Laboratory with a twofold purpose in mind: (1) to discover the illumination intensities preferred for reading under each of a variety of lighting situations; and (2) to clearly define the role of visual adaptation as a factor in illumination preferences. An attempt was made to maintain adequate controls in the experimental designs employed. Coordination of the results from the whole series of experiments should provide data for evaluation of the light preference technique.

PRELIMINARY EXPERIMENT NO. 1

In this study which was concerned with a type of direct lighting,

the objective was to determine illumination preferences following initial adaptation to a low level of intensity. To simulate conditions found in many homes where light from floor lamps with open-faced shades are used for reading, a bank of light bulbs mounted on a standard was employed. An open-faced white cloth shade surrounded the fixture. The subject sat with the light coming over the right shoulder to reading material placed on a reading stand 40 inches from the light fixture. By means of a rotary switch operated by the reader, lighting of the bulbs was controlled so that a range of intensities from 1 to 50 footcandles on the reading material was possible.

Fifty-three university students served as subjects. All testing was done individually. On entering the laboratory, each subject adapted for 20 minutes to a general illumination of 4 footcandles. Then the subject was asked to adjust the light, by moving the switch, to the brightness that he liked best for comfortable reading. The general illumination was turned off as the local lighting was turned on. After five minutes of reading, the light was readjusted by the reader. This was done for six successive periods. Recordings of the light intensity chosen were made from a Westinghouse Light Meter at the beginning of the first period and at the end of each of the six five-minute periods. A magazine printed in 9 point type, 2 point leading and in an 18 pica line width was used as reading material. The paper was moderately glossy.

Under condition A, approximately one-half of the subjects started at one footcandle and increased the intensity of the desired brightness. The other half, under condition B, started at 50 footcandles and reduced the brightness by the desired amount. Twenty-two readers served under both conditions. The results are given in Table 1.

TABLE 1

Mean Illumination Intensities in Footcandles Preferred for Reading Under Direct Light from a Modified Floor Lamp
Note: Initial adaptation was to 4 footcandles.

Number of Subjects	Initial Choice	Successive Five-Minute Periods						Total
		1	2	3	4	5	6	
Condition A: Light increased from low intensity.								
36	14.4	19.6	22.4	22.4	23.2	24.6	24.9	21.5
Condition B: Light decreased from high intensity.								
39	29.2	27.2	29.5	27.9	28.3	28.6	28.7	28.9

Inspection of the table reveals that when the subjects began at a low intensity (condition A) and increased the illumination to the chosen value, there was an increase in preferred intensity through the

first 10 minutes, the choices were fairly constant for the next 10 minutes, and then a slight increase occurred during the last 10 minutes. The overall mean was 21.5 footcandles. When the subjects started with high intensities (condition B), the choices were fairly stable from the first. The overall mean was 28.9 footcandles. In general, the trends indicate that when a reader is initially adapted to a low level of 4 footcandles intensity, he reaches his final choice promptly when starting with bright illumination, but when starting with low intensities he does not reach his final choice until he has read for a while under a light somewhat brighter than his adaptation level. Furthermore, when starting with low intensities, his mean choice of the best intensity for comfortable reading is somewhat lower (21.5 footcandles) than when starting with high intensities (28.9 footcandles). In view of the experimental procedure, it would seem that this difference is due to the changes in visual adaptation occurring during the 30 minutes of reading. In a supplement to this experiment, three readers observed in the same manner (30 minutes of reading) on each of five successive sittings one week apart. The results were approximately the same as shown in Table 1. Apparently, visual adaptation at time of choice determines to some degree the light intensity preferred for comfortable reading.

EXPERIMENT NO. 2

In the above experiment the illumination was not strictly localized on the reading stand. Considerable light spread about the room due to the nature of the fixture. In Experiment 2, a fixture which concentrates the major portion of the light on the reading stand was employed. Because of poor distribution of light, this situation is bad from the standpoint of hygiene of vision. The purpose was to determine illumination intensities preferred for comfortable reading when the light is direct and strictly local and when the readers are initially adapted to a low level of illumination.

Six standard, metal shade, flexible arm reading lamps equipped with frosted bulbs constituted the light sources. The fairly uniform spot of illumination on the reading stand was about 10 inches in diameter. From the perimeter of this area outward, the illumination decreased rapidly in intensity. Five watt to one hundred watt bulbs were used, yielding illumination intensities at the reading surface of from 3 to 160 footcandles. Otherwise the reading situation was the same as in Experiment 1.

Thirty university students served as subjects. All had normal or adequately corrected vision. The initial adaptation period was for

15 minutes to a general illumination of 3 footcandles, the same as the lowest intensity of the direct lighting. The lamps were moved in and out of position by the experimenter.

The procedure was as follows: Near the end of the adaptation period the subjects were told that they were to choose the brightness of light which they considered best for comfortable and efficient reading, i.e., a light which would provide clear seeing of the print, prevent eye strain, produce no annoying glare, and allow easy reading. The subjects were then shown each of the intensity levels and allowed to read a few seconds under each one, from lowest to highest. Then, again starting with the lowest intensity the experimenter proceeded upward until he came to the one preferred by the subject for reading. The subject was allowed to read for five minutes under the light chosen and then to choose another or keep the same one as the final choice. The procedure was repeated until five five-minute periods were completed and five final choices made.

TABLE 2

Illumination Intensities in Footcandles Chosen for Comfortable Reading Under Localized Direct Lighting (N = 30 University Students)
Note: Initial adaptation was to 3 footcandles.

	First 5 Minutes	Second 5 Minutes	Third 5 Minutes	Fourth 5 Minutes	Fifth 5 Minutes	All 5 Periods
Mean	31.7	38.2	50.1	46.6	46.4	42.6
S.D.	20.0	16.1	33.6	20.8	20.3	17.4

Mean scores for the preferred levels of illumination are shown in Table 2. There were marked individual differences in the choices as shown by a range of from 10 to 84 footcandles. This is reflected in the relatively large variabilities. Median values showed the same trend as the means. The mean scores increase up to the third five-minute period and are relatively stable from there on. Since the subjects were adapted initially to 3 footcandles they apparently were satisfied at first with somewhat lower intensities for reading. As they worked with the brighter lights, adaptation changed and they tended to choose somewhat brighter illumination. This trend corresponds with the findings in Experiment 1.

Under the strictly localized lighting in this experiment, the overall average for preferences was 42.6 footcandles. This mean is considerably larger than in Experiment 1 where the overall means were 21.5 and 28.9 footcandles. Three factors may be involved in this difference: (1) In Experiment 2 the lighting was strictly local. Even casual observation indicates that readers tend to choose relatively bright intensities under this condition. (2) The range of intensities

was much greater in Experiment 2 (3 to 160 footcandles) than in Experiment 1 (1 to 50 footcandles). When this holds, preferences tend to be higher as noted in the above survey of the literature. (*3*) The readers were allowed to explore with considerable freedom over a wide range of intensities.

In these two experiments it was difficult to control visual adaptation to light intensity for any appreciable length of time. To correct this difficulty, a different experimental design was employed in the next study.

EXPERIMENT 3

The purpose in this study is to determine illumination intensities preferred for comfortable reading under strictly localized lighting with a rigid control of visual adaptation. The experimental situation, with regard to laboratory room, reading stand, and light fixtures, was the same as in Experiment 2.

Sixty university students served as subjects, one at a time. There were two sessions of 50 minutes for each subject. At one sitting the subject was adapted to 20 footcandles of light; at the other, to 50 footcandles. Half of the subjects began with 20 footcandles, the other half with 50.

On arrival at the laboratory, a subject spent 15 minutes adapting to the standard illumination (20 or 50 footcandles). Near the end of this period he was shown a sample of the material to be read. This material was a story printed in 11 point type with 2 point leading and a 23 pica line width on mat white paper. At the end of the 15 minutes the following directions were read to the subject:

"I am going to ask you to decide which of several brightnesses of light you prefer for reading. Decide in terms of the light which seems most comfortable for reading. You will be asked to read a few lines under a standard light—the one now on—and then under a comparison light. After trying this a couple of times, you will choose which light you prefer for reading the printed material. After your choice, other lights will be compared with the standard in a similar manner."

Ten seconds after notifying the subject that the light now on was one of the lights to be compared, the standard was switched off and simultaneously the comparison light was switched on. Ten seconds later the whole procedure was repeated and then a choice requested by asking, "Do you prefer this or this." The subject was readapted for 2 minutes to the standard intensity prior to the next choice. The 20 footcandle standard was compared with 4, 10, 50, 75,

and 100 footcandles in a random order. The 50 footcandle standard was compared with 4, 10, 20, 75, and 100 footcandles under similar conditions. Thus each subject had five choices under each of the two conditions of adaptation. All illumination intensities were checked every day with a recently calibrated General Electric Footcandle Meter.

Since the standard intensity was compared with each of the five other intensities, it appeared five times as often as each of the comparison lights. The frequency of choice of the 20 and of the 50 footcandles, therefore, was divided by five to make these figures comparable to the others. The results of the adjusted data are shown in Table 3. In the top section of the table each of the listed foot-

TABLE 3

Frequency with Which Illumination Intensities Were Preferred for Reading with Direct Lighting After Adaptation to a Standard Intensity ($N = 60$ University Students)

	Adapted to 20 Footcandles (Standard)					
Footcandles Compared	4	10	20	50	75	100
Times Preferred	13	15	29	46	42	41
Per Cent	7	7	16	25	23	22
	Adapted to 50 Footcandles (Standard)					
Footcandles Compared	4	10	20	50	75	100
Times Preferred	13	13	16	37	35	37
Per Cent	9	9	11	24	23	24

candle values was compared with the standard of 20 to which the subject was adapted. This part of the table is to be read as follows: When adapted to 20 footcandles, 4 footcandles was preferred over 20 13 times or 7 per cent; 10 footcandles was preferred 13 times or 7 per cent, etc. The bottom section of the table is to be read in a similar manner. Here 50 footcandles was the standard. In interpreting the data in Table 3 it should be remembered that each intensity was compared with the one to which the subject was adapted.

Examination of the data in this table reveals that visual adaptation at the moment appears to determine to some degree the choices made. Actually, before the data were adjusted as noted above, there were 145 choices at 20 footcandles when adapted to 20 footcandles, and 186 choices at 50 footcandles when adapted to 50. Although the range of choices was from 4 to 100 footcandles when adapted to either 20 or 50 footcandles, there were relatively few choices for intensities below that to which the subject was adapted. Irrespective of the intensity to which the subject was adapted, 50, 75 and 100 footcandles were most frequently preferred in the adjusted data. These results agree with

those in Experiment 2 in that with strictly local lighting, readers prefer relatively high intensities.

This preference for relatively bright illumination for reading under strictly localized lighting has unfortunate implications for the hygiene of vision. As noted by Tinker,[6] a small spot of bright light surrounded by dimly illuminated areas and shadows in the visual field provides a situation that rapidly produces visual fatigue. The lack of uniform distribution of illumination in the visual field is bad. Furthermore, in a situation of this kind, the greater the intensity of illumination in the limited area of the reading stand, the worse it becomes for visual work since the demarcation between the small bright area and the dimly illuminated surroundings becomes more pronounced.

EXPERIMENT 4

The purpose of this experiment is to measure the degree to which the illumination intensity chosen for comfortable reading is determined by the illumination level to which the eye is adapted when reading under general, well-diffused light.

The light laboratory and reading stand used was the same as in Experiments 2 and 3. Indirect illumination from a series of Pittsburgh Permaflector luminaires yielded any desired intensity between 1 and 100 footcandles. A total of 144 University students served individually as subjects for two sittings of 50 minutes each. At one sitting the subjects were adapted to 8 footcandles of light; at the other, to 52 footcandles. Half of the subjects began with 8, the other half with 52 footcandles. Initial adaptation was for 15 minutes. Near the end of this period, the subjects were shown the printed material that was to be read. It was a story printed in 11 point type with 2 point leading in a 22 pica line width on mat white paper. At the end of the adaptation period, the following directions were read to the subject:

"You are to make comparisons between different brightnesses of lighting. You are to decide which of two illuminations you prefer for comfortable reading. Read 3 or 4 lines under each light noting how the print looks and then make your choice. You will be shown each light twice before the choice is required."

As in Experiment 3, 10 seconds after notifying the subject that the light now on was one of the lights to be compared, the standard was switched off and simultaneously the comparison light was switched on. Ten seconds later the whole procedure was repeated and then a choice was requested. The subject's eyes were readapted to the standard intensity for 4 minutes before the next comparison was made.

The 8 footcandle light was compared with 1, 2, 3, 5, 12, 18, 26, and 41 footcandles taken in random order. The 52 footcandle standard was compared with 18, 30, 41, 46, 59, 62, 71, and 100 footcandles. Thus each subject made eight choices under each of the two conditions of adaptation. Illumination intensities were checked every day with a recently calibrated General Electric Footcandle Meter.

TABLE 4

Effect of Visual Adaptation Upon Intensity of Illumination Preferred with General Illumination After Adaptation to a Standard Intensity (N = 144 University Students)

	Adapted to 8 Footcandles (Standard)								
Footcandles Compared	1	2	3	5	8	12	18	26	41
Times Preferred	0	5	6	18	107	98	70	57	48
Per Cent	0.0	1.2	1.5	4.4	26.2	24.0	17.1	13.9	11.7
	Adapted to 52 Footcandles (Standard)								
Footcandles Compared	18	30	41	46	52	59	62	71	100
Times Preferred	25	37	53	65	98	54	55	42	35
Per Cent	5.4	8.0	11.4	14.0	21.0	11.6	11.9	9.1	7.6

The results are shown in Table 4. Since the standard intensity was compared with each of the eight other intensities, it appeared eight times as often as each of the comparison lights. To make the data for the 8 and 52 footcandles comparable with that for the others, the frequencies of choice for these values were divided by 8. The adjusted data are given in the table. The table is to be read as follows: When adapted to 8 footcandles as a standard, 1 footcandle was preferred over 8 footcandles zero times; 2 footcandles was preferred over 8 footcandles 5 times or 1.2 per cent, etc. The lower section of the table is read in a similar manner.

It is clear from the trend of the data that the illumination to which the subject is adapted plays a dominant role in the preferences. When adapted to 8 footcandles, the 8 footcandles was chosen most frequently, and 12 footcandles next most frequently. Before adjusting the data as noted above, there were 856 choices for the 8 footcandle intensity. When adapted to 52 footcandles, preference for the standard was even more striking. Before adjusting the data, there were 784 choices for the 52 footcandle intensity. The percentages reveal to better advantage the distribution of the preferences.

Individual differences in the preferences are noteworthy. When adapted to 8 footcandles, the choices ranged from 2 to 41 footcandles, with relatively few below 8. And when adapted to 52 footcandles, the choices extended throughout the range from 25 to 100 footcandles. This distribution of frequencies is fairly normal in shape.

DISCUSSION

The present paper is concerned with coordinating the results from a series of experiments on the intensity of illumination preferred for comfortable reading. The details of methodology and results are given in the original papers.[5, 6, 7]

Examination of previously published studies suggested that visual adaptation at the time the preferences are made is involved. Several studies were conducted to investigate to what degree visual adaptation is involved in determining intensities chosen for comfortable reading.

In the first two experiments which were concerned with direct lighting, subjects were initially adapted to 3 or 4 footcandles of illumination and then were allowed to explore over a range of intensities while reading for a series of successive five-minute periods. Preferences were expressed at the end of each five minutes. It was found that although the initial adaptation to a low level of intensity had some effect on the choices when the exploring was from low to higher intensities, this effect soon disappeared as the eye readapted to the higher intensities chosen for reading during the early five-minute periods. The initial adaptation apparently had no effect on preferences when the exploring was from high to lower intensities. Furthermore, the greater the range of intensities available, the brighter the light chosen for comfortable reading.

It is well known that the eye adapts very rapidly to bright light. This adaptation is practically complete by one minute or a little more. With this in mind, the results in Tables 1 and 2 become clear. As soon as the subjects had become adapted to the intensities they were allowed to explore, the preferences became stabilized as revealed in the trends of the data in these tables. The results in Experiments 1 and 2, therefore, are not contrary to the view that visual adaptation at the moment affects preferences for illumination intensities for comfortable reading.

Experiment 3, also concerned with preferred light intensities for comfortable reading under direct lighting, employed an improved design which permitted the maintaining of adaptation at a constant level. When adapted to 20 footcandles, the preferred intensities were mostly at 20 footcandles or above. And when adapted to 50 footcandles, the preferences were concentrated at 50 footcandles and above. Obviously the intensity to which the eye is adapted prevents most readers from choosing intensities below that level (Table 3).

In Experiment 4, concerned with preferences for desirable intensities while reading under general illumination, the trends are some-

what different. Here the adaptation was maintained constant as in Experiment 3. Under the general, well-diffused illumination, the preferred intensities were concentrated at or near that to which the reader was adapted. In such a situation it is obvious that visual adaptation plays a dominant role in determining what level of illumination a reader prefers for comfortable reading.

Evidence from this series of experiments indicates that visual adaptation exerts considerable influence on what illumination intensity will be chosen by a reader as best for comfortable reading. To some degree, one can control the preference by controlling visual adaptation. Individual differences in preferences, however, should not be ignored. In any one of the four studies, the variation in preferences is great, extending in most cases over the entire range of intensities explored. In view of the results obtained, it is not surprising that preferred light intensities frequently fail to coincide with results involving objective measurements for determining the illumination intensities needed for efficient visual work. Tinker's analysis[8] of the literature indicates, for instance, that 20 to 25 footcandles is adequate for efficient and easy reading of 11 point print. The preferences in Experiment 4 described above, however, show wide divergencies from this range.

The results obtained in this series of experiments would seem to justify the conclusion that the intensity of light preferred for reading cannot be a valid measure of the illumination needed for efficient visual work. Light preferences, therefore, should not form the basis, either as primary or as supplementary data,[2] for recommended standards of illumination. Furthermore, preferred intensity of light should not be used to persuade a consumer that one intensity is better than another for ease and efficiency in reading.

SUMMARY

1. A series of four experiments was carried out to study preferences for illumination intensities for reading with special reference to the role of visual adaptation as a determinant of the preferences.

2. From 30 to 144 subjects were employed in the different experiments.

3. In Experiments 1 and 2 the subjects were initially adapted to a low intensity (3 or 4 footcandles) and then allowed to explore over an extensive range of intensities while reading under direct lighting prior to choosing an intensity best for comfortable reading. Initial adaptation influenced the choices only during the first few minutes of reading. After readaptation to the intensities explored, the subject tended to choose higher footcandle levels for their reading. When high

intensities were explored first, the initial adaptation had no effect at all on the choices.

4. In Experiment 3 (also direct lighting), visual adaptation was kept constant at either 20 or at 50 footcandles. Under these conditions, the intensities preferred for comfortable reading were concentrated at or above the level of adaptation.

5. In all three experiments with direct lighting, the greater the range of intensities of illumination explored by the reader, the greater the intensity preferred for reading.

6. In Experiment 4 (general illumination) the subjects were adapted to 8 footcandles at one sitting and to 52 footcandles at another sitting. Adaptation was maintained constant. The preferred intensities for reading were concentrated at or near that to which the subject was adapted.

7. The pattern of results from all four experiments indicates that visual adaptation at the time the choice is made is an important determinant of the intensity preferred for comfortable reading. In fact, one can control to a considerable degree the choice by controlling the intensity to which the subject is adapted.

8. From these results, one must infer that the intensity preferred by a reader should not be employed as a basis for prescribing illumination for efficient seeing.

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MAGNIFICATION FOR NEAR VISION*

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The importance of near vision in industry hardly needs to be stressed. With the tremendous expansion of industry, especially within the last twenty years, a large percentage of our total national population now is engaged in continuous near vision. The visual tasks, of course, are varied; however, many of them require a maximum of visual resolution, especially at short distances of fixation.

Practically everyone who attempts to perform a visual task with the two eyes at short distances experiences discomfort. Personal experiences of reading a finely calibrated micrometer or attempting to thread a needle are illustrations of the problem. Since such tasks or their equivalents are often continued throughout a working day, it is clear why many employees cannot perform adequately on such a job and need some kind of visual aid.

In any task requiring the maximum visual resolution, an attempt is invariably made to bring the object as close as possible to the eyes. The reason, of course, is that the size of the retinal image is inversely proportional to the distance of fixation. Since the mosaic of the retina is constant, this method frequently provides a means for obtaining

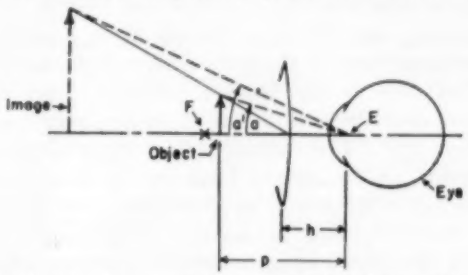

Fig. 1.—Optical principle of a magnifying lens; *E*, the reference point for computing angular magnification, represents center of eye's entrance pupil.

the necessary resolution. If the discussion is limited to a single eye, the only exception would be those individuals who had lost the faculty

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of changing the power of the eye, i.e., accommodation. In these cases, the loss in resolution due to a blurring of the retinal image will more than offset any gain procured by use of the near distances. See Figures 1, 2, 3, and 4.

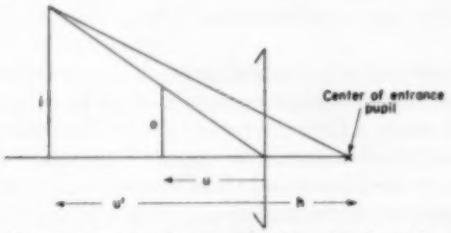


Fig. 2.—Method of computing angular magnification, showing object (o), image (i), and their distances, respectively, from magnifying lens (u and u').

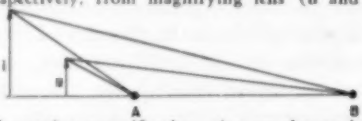


Fig. 3.—Variation of angular magnification, due to change in position of reference point: points A and B used for computing angular magnification.

For individuals with a normal range of accommodation, it is often desirable to employ a lens to reduce the demand on accommodation when viewing objects at near distances. In common parlance, such a lens is called a magnifier.

ANGULAR MAGNIFICATION

In computing angular magnification, it is necessary to employ some reference point within the eye. Although a number of different reference points such as the primary principal point or first nodal point of the eye could be used, by far the most satisfactory is the center of the entrance pupil. The entrance pupil is the virtual image of the real pupil formed by the cornea. Since the center of the entrance and exit pupils are conjugate points, an alteration of the angular magnification at the entrance pupil produces a proportional change in the angular size of the retinal image measured from the center of the exit pupil. An additional advantage of the entrance pupil as a reference point is that all equations relating to it are valid for both in-focus and out-of-focus imagery.

In order to compute the angular magnification of a lens before an eye, the following relation can be used:

$$M = \frac{\tan a'}{\tan a} = \frac{1}{1 - \frac{h}{p}\left[\frac{p - h}{f}\right]} \qquad (1)$$

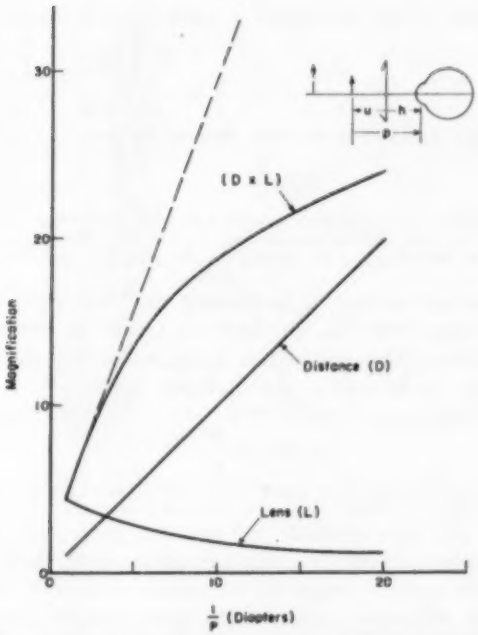


Fig. 4.—Change in size of retinal image, produced by angular magnification of +20-diopter lens, plotted on curve *L*, change resulting from alteration of objects's fixation distance marked *D*; curve for product of two changes marked *D* x *L*.

In deriving this equation, care has to be given to the directional values of the distances. Thus, p, h, and f are positive only when measured in the same direction as the incident light, e.g., from left to right. In Equation 1, as $(p - h) \rightarrow f$, it is seen that:

$$M = I + hF \qquad (2)$$

For this condition, the object is located at the primary focal point of the lens, and the image then is located at infinity. Obviously, Equation 2 expresses one limit for the magnification from variation of the distance of the object from the lens. The second limit is determined by the available amplitude of accommodation. For in-focus retinal imagery, the image of the object cannot be less than the near point, e.g., the shortest distance for which one is able to accommodate.

Due to the variability of accommodation several other methods also have been used to compute angular magnification.[1] Both of the methods utilize what is commonly called "the least distance of distant vision." Somewhat arbitrarily, this distance has been assumed to be 25 cms. In the one method, the magnification is given by the ratio of the angular size of the image at any distance to the angular size of the object at the least distance of distant vision.

These relations are seen in Figure 2. In the figure, o and i represent the object and image, respectively, and u and u' the object and image distances measured from

the lens. If d stands for the least distance of distant vision, it follows that:

$$M = \frac{i}{h - u'} \Big/ \frac{o}{d} = \frac{d\left[\frac{1}{f} - \frac{1}{u'}\right]}{1 - h/u'} \qquad (3)$$

Now, if the object is located in the focal plane of the lens,

$$M = \frac{d}{f}. \qquad (4)$$

This value is known as the effective magnification: its chief value is simplicity. Its greatest shortcoming is the lack of consideration for the most effective means of increasing the size of the retinal image by placing the image at the least distance of distant vision.

In the second method, it is assumed that the object without the lens and the image with the lens both are located at the least distance of distant vision. This method is more reasonable since either the object or image can be seen at the same near point.

Again, with reference to Figure 2, when $d = -u'$, and $h = o$,

$$M = 1 + \frac{d}{f}. \qquad (5)$$

This value is defined as conventional magnification. Obviously, it is not always desirable to have $h = o$, especially when a lens is to be used binocularly.

Each of the three methods for computing the magnification has certain limitations. However, with a cognizance of their limitations, each one can be usefully employed for certain needs and circumstances. For simplicity of presentation in the remainder of this paper, all references to angular magnification will be based upon Equation 1.

It is apparent from a study of Equations 1 and 2, that the angular magnification varies with the distance of the lens from the eye. The reason for this change is clearly illustrated in Figure 3. In this figure, A and B represent two positions of the reference point with respect to the lens. It is seen that the angular magnification is largest for the longest distance from the lens to the eye.

Although it is possible to obtain an increase in magnification by increasing the distance of the magnifying lens from the eye, the increase is more than offset by the diminution in size of the retinal image due to the greater distance of observation. As pointed out previously, the size of the retinal image is inversely proportional to the distance of fixation. These effects are illustrated in Figure 4, for the lens of +20.00 diopters. For the curve, the distance of the object, i.e., u, was 0.04 meters, and h and thus p were varied. The lowest curve on the graph, i.e., the one marked L, is the angular magnification produced by the lens. The intermediate curve marked D, is the relative magnification due to the change in distance of fixation of the object: for reference, the magnification at one meter was assumed to be unity. The product of the magnifications due to both of these factors is labeled $D \times L$. It is interesting to note from this curve that the rapid increase in magnification ceases for approximately five diopters, i.e., a value for p of only 20 cms. These results indicate an optimal distance for position of a magnifying lens before an eye: it varies, of course, with the power of the lens.

From a study of Figure 4, it is obvious that shorter distances for h, and thus p, than the optimum might be used to obtain increased magnification. Such a procedure is satisfactory provided that a fixed distance between the object and the lens (i.e., u) is employed. This condition usually can be met if the lens is not worn in a spectacle and, instead, is held in position by a stationary mount. If the lens is worn as a spectacle, it is necessary to consider the changes in stimulus to accommodation resulting from a variation of u. These effects for lenses of different power are shown in Figure 5.

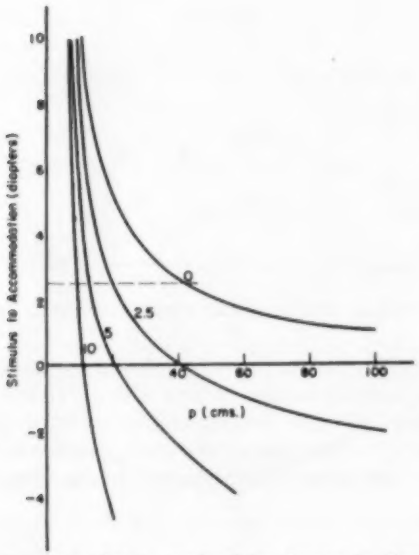


Fig. 5.—Stimuli to accommodation, produced by changes in distance between object and magnifying lens.

The stimulus to accommodation is plotted as the ordinate, and p as the abscissa. For all data, h was constant and assumed to be the average vertex distance for spectacles of 13 mms. The numbers on the different curves indicate dioptral power of the lenses. From a study of the data, it is seen that small changes of u, and thus p, produce marked stimuli to accommodation for lenses of strong power. The plus and minus values indicate a necessity to increase and decrease, respectively, the power of the eye to maintain a clear image on the retina. Since it is not possible to decrease accommodation below the zero level, a blurred image would result and thus the necessity to make an adjustment of the head to obtain a clear image. For plus values of stimuli to accommodation, accommodation could be used. However, excessive use of this function undoubtedly would produce fatigue even if the lens were to be used monocularly. If lenses were employed binocularly under these conditions, excessive strain or double vision would be experienced. On the basis of the reasons given above, the power of the lenses used for magnification and worn as spectacles should always be kept to a minimum.

ROLE OF CONVERGENCE

Under ordinary conditions, when an object is brought close to the eyes for magnification, one must not only accommodate but also converge the eyes. In distant vision, the lines of sight are parallel; for successively closer points of fixation various amounts of convergence have to be used, Figure 6. Usually, the relationship between accommodation and convergence is such that one can accommodate and converge for points relatively close to the eyes. If accommodation occurs without convergence or vice versa, usually satisfactory binocular vision cannot be maintained.

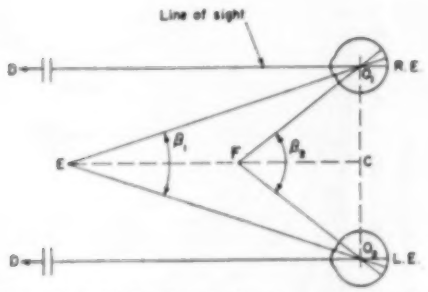


Fig. 6.—Parallel lines of sight in distant vision: convergence for single vision for point E is β_1.

As pointed out earlier, lenses employed for magnification reduce the demand on accommodation in near vision. If such lenses are used binocularly, they alter the normal requirements of convergence with accommodation. For this reason, one must compensate for the demand on convergence and bring it into proper relationship with accommodation.

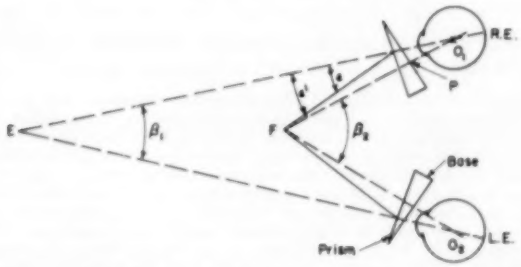


Fig. 7.—Convergence of right and left eyes on image E, the base-in prisms reducing the required convergence for singular binocular vision from β_2 to β_1.

Just as the demand on accommodation for a near point of fixation can be reduced by the use of lenses so also the demand on convergence can be lessened by the employment of prisms. Figure 7. To accomplish this objective, the bases of the prisms always have to be "in." In Figure 7, the prisms have reduced the required convergence for single binocular vision from β_2 to β_1. If $e' = (\beta_2 - \beta_1)/2$, the power of the prisms can be computed by the relation:

$$e = \frac{e'(u - s)}{u} \qquad (6)$$

In this equation, $u = PF$, and
$s = PO_1$.

Whenever the prisms are worn as spectacles at the normal vertex distance, the distance PO_1 is approximately 0.027 meters.

Usually convergence and prismatic power are specified in prism diopters. If b represents the interpupillary distance for distant vision, the convergence in prism diopters for point E in Figure 6 is given by:

Equation of aspheric curve:

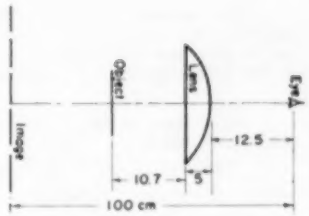
$z = a_0x^2 + a_1x^4 + a_2x^6 + a_3x^8$

when x and z are given in decimeters

$a_0 = 0.5736$ $a_2 = 0.4284$

$a_1 = -0.2896$ $a_3 = -0.2430$

x mms	z mms	x mms	z mms
20	2.251	80	32.001
40	8.596	90	39.765
60	18.487	100	46.936



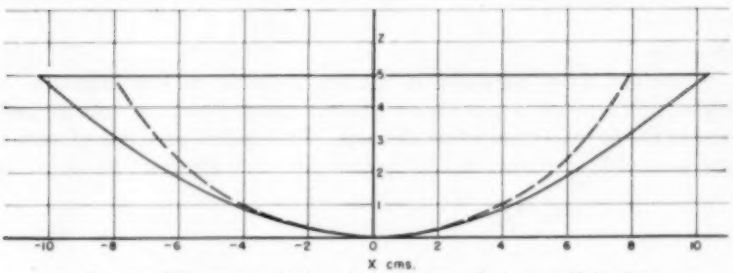


Fig. 8.—Typical specifications for a plano-aspheric magnifying lens.

$$\beta_2 = \frac{b \text{ (cms)}}{EC \text{ (meters)}} \qquad (7)$$

This equation similarly can be used for other points of fixation: thus e' and e are easily computed in prism diopters.

In the usual design of a binocular magnifier, the lens providing the magnification is decentered in to produce the desired prismatic effect. This is done by the relation:

$$e = cF \qquad (8)$$

in which e is the prismatic deviation in prism diopters, c is the decentration of the lens in centimeters, and F is the power of the lens in diopters.

Although the above relations permit the design of a binocular magnifier with a normal relation between accommodation and convergence, it frequently is desirable to alter the prismatic effect to suit the particular needs of an individual. Thus, if the eyes under dissociation ordinarily tend to diverge, the base-in prismatic effect can be increased.

RECENT DEVELOPMENTS IN MAGNIFIER DESIGN

Monocular

The most persistent problem encountered in the design of magnifiers is the reduction in the field of view with an increase in magnification. For example, if one attempts to use (monocularly) a wide aperture lens at a distance of 10 to 15 cms. from the eye and the lens is ground with only spherical curves, excessive distortion is encountered, as a rule, in all but the centermost portion of the image. Such distortion, however, can be eliminated by designing an aspherical curvature for one surface.

The mathematical theory for the design of aspheric surfaces for monocular magnifiers has recently been developed by two investigators.[3, 4] In general, it is based on the third and fifth order distortion properties of a lens and necessitates the solution of the following or similar equation:

$$z = a_0x^2 + a_1x^4 + a_2x^6 + a_3x^8.$$

An example of the use of this equation in the design of a plano-aspheric lens is given in Figure 8.

Ordinarily, it is difficult to fabricate aspheric surfaces. However, with the recent developments in the molding of plastic materials, especially by the drop method, the task is no longer considered insurmountable.

Binocular

For industrial purposes, it is often desirable to have available a single large lens on a stationary mount. Such lenses, of course, find greatest use in inspection of small parts. The optical principle of such a lens is shown in Figure 9. No matter at what distance the object is

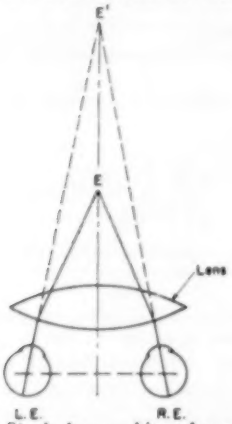


Fig. 9.—Single lens as binocular magnifier.

viewed, the normal relationship between accommodation and convergence is maintained. Such a lens provides what is known as an orthoptic condition.

The principal problem of a single lens used as a binocular magnifier is illustrated in Figure 10. The upper drawing in this figure shows the relative positions of the images of the right and left eyes, as well as the combined binocular image, for a flat object viewed through the lens. It is seen that the two eyes are required to fuse two completely different images and that the normal relationship between accommodation and convergence is seriously disturbed, especially towards the edges of the field of view. In addition, the monocular fields extend considerably beyond the binocular fields and this leads to a sharp discontinuity of viewing conditions.

In order to correct these conditions, one or both of the surfaces of a lens can be made aspheric. The effect of such a correction is also shown in Figure 10. It was achieved by aspherizing the surface remote from the eye and in this case the generator is a conic, having the equation:

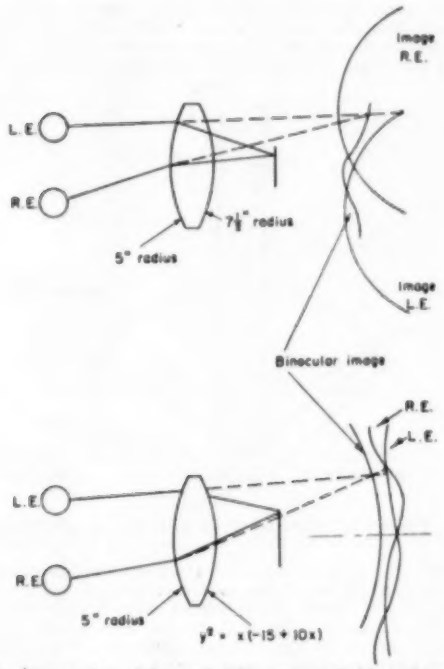


Fig. 10.—(Top) Images for right and left eyes, and binocular image as viewed through a lens with only spherical surface; (bottom) effect of aspherizing surface of lens remote from eyes.

$$y^2 = x\ (-\ 15 + 10x)$$

using Cartesian co-ordinates with the usual sign conventions.[2] Lenses of this design fabricated in plastic materials and in several powers are available from the Imperial Chemical Industries, Ltd., England.

Projection

Projection magnifiers have been utilized extensively in industry for a number of years. However, a novel form of the projector, especially suitable for examining the surface finish of metal and other similar objects, has been introduced recently.[6] The novel feature of the instrument is the employment of the optical principle of a reflecting microscope instead of the microscope type of objective generally used in profile projectors. The obvious advantage of the former is that, since reflection is used instead of refraction, chromatic aberration is entirely eliminated.

The optical principle of the reflecting microscope is illustrated in Figure 11. The optical elements consist of a large concave silvered mirror and a smaller convex mirror. The object to be examined is located below the convex mirror. The light from the object passes upwards in the form of a wide-angle cone around the edge of

the convex mirror onto the inner surface of the concave mirror. From here it is reflected downward onto the convex mirror which reflects it upwards through an aperture in the center of the concave mirror to form an enlarged image on a translucent screen placed at a convenient distance above the concave mirror. In the projector, the

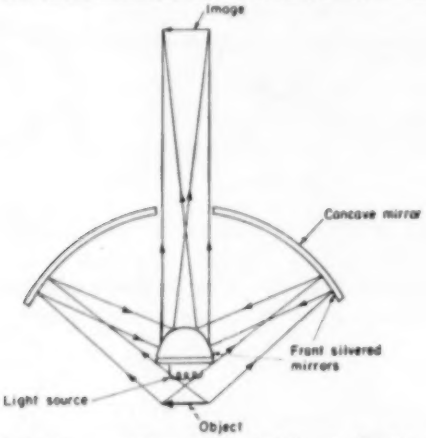


Fig. 11.—Projection magnifier, using principle of reflecting microscope.

optical components (indicated in Figure 11) are inverted: the object to be examined is placed above the plane surface of the convex mirror and the concave mirror is fixed below the convex mirror. Plane, front surface mirrors alter the path of the image between the concave mirror and the image so that the location of the viewing screen is in a convenient position. In the available instrument, the translucent screen is 16 inches in diameter and the standard magnification is about 38X.

Another new design of a projection magnifier is depicted in Figure 12. It was developed primarily for individuals with subnormal vision and is most useful for magnification of printed material. The optical system consists of a projection lens and two mutually perpendicular mirrors; each mirror is used twice in the magnifying process. The lens, centered on a plane bisecting the right angle between the mirrors, transmits light from the object to both mirrors near their line of intersection. Each mirror reflects this light to the remoter area of the other whence it is again reflected and then focused upon a translucent screen. With this arrangement, the image is not inverted and the material to be read is placed under the lens right side up. The fact that there is no inversion of the image makes for convenience in the use of the magnifier. The reader moves the material naturally in the proper direction and page turning is easily accomplished. The standard magnification of the unit is 5X. By substituting a lens of three-inch focal length for the standard two-inch focal length, the magnification is changed from 5 to 3X.

Because the lens and mirror system is stationary, lateral scanning, as reading a line of print in a book, is possible by moving the book from side to side under the lens. For this purpose, a carriage has been mounted on fiber bearings which allows motion in this direction. Also, the tracks for the fiber bearings are mounted on journal bearings at right angles to permit front to back motion. The light source for the magnifier is supplied by two 40-watt internal reflecting showcase lamps. The translucent screen essentially is an etched Fresnel plastic lens: it produces maximum economy in use of the available light in the image. Due to the lightness in weight and relatively small size of the whole instrument, it is portable.

As shown above, one can project the magnified image of an object on a screen located at a comfortable viewing distance, instead of

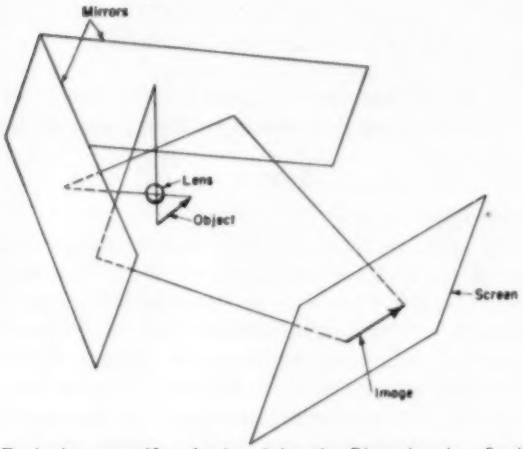


Fig. 12—Projection magnifier developed by the Bioengineering Section of the Franklin Institute Laboratories for Research and Development, Philadelphia, Pa., but not yet commercially available.

reducing the distance of fixation, in order to obtain an enlargement of the retinal image. Such a procedure avoids the problem of excessive stimuli to accommodation resulting from the use of very short viewing distances.

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CONTACT LENSES: SOME ASPECTS OF VISUAL ACUITY AND PHOTOPHOBIA*

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PART II.

TESTING OF PHOTOPHOBIA

It became apparent from the pilot studies on visual acuity with contact lenses in place, that photophobia frequently became a factor of considerable influence. Therefore, an attempt was made to evaluate this phenomenon. In the field studies, this effect was limited to subjective comment, this being qualitative in nature. However, in the laboratory, attempt was made to obtain some quantitative measure of tolerance to light. The equipment developed for the testing of visual acuity served this purpose well, for with it, it was possible to control the amount of light supplied to the target and to the surround.

Tolerance to target and surround illumination, or point of onset of photophobia was tested at the fifty centimeter distance. Three levels of target brightness were considered in testing ambient tolerance in order to determine the effect, if any, this factor produced. These levels conformed to the target brightness used in a given day, being either one, twelve or one hundred foot Lamberts. Target tolerance was tested in the presence of no surround illumination.

On the basis of the work of Peterson and Simonson,[10] who found that in young individuals, glare had no effect on accommodation tested under situations where ocular irritation was not present, it was felt that work conducted at fifty centimeters would be valuable.

A typical test at fifty centimeters was run as follows. If the target for a given day was one foot Lambert, a reading of visual acuity was first taken with zero footcandle surround illumination. A visual acuity reading was defined as the threshold determination recorded when the subject was able to answer correctly the three out of four presentations offered. Before further testing, surround tolerance

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was determined by turning the variac slowly until the subject could no longer "tolerate" the light. Following this, three visual acuity readings were taken at each of three levels of surround illumination—one hundred, two hundred, and three hundred foot candles with an appropriate light adaptation period of one minute before each reading.

After this, the surround illumination was reduced to zero and again a period of one minute was spent adapting to a standard target brightness of twelve foot Lamberts. Following this the variac was slowly turned up until the level of the target tolerance was determined. The entire test procedure took approximately six minutes, and each subject took one reading an hour. Means of hourly readings of the subjects were calculated and plotted against time after insertion.

SPECTACLES

RESULTS

At the levels tested of both target brightness, Figures 16 and 18,

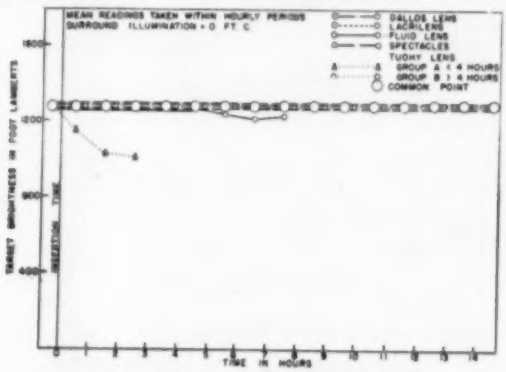

Fig. 16. Tolerance to Target Brightness.

and surround illumination. Figures 17 and 19, subjects wearing spectacles experienced no photophobia under normal conditions, and climatic extremes, or high altitude. As the results in the low pressure chamber followed the same trend as those recorded under normal conditions, these graphs are not shown.

DISCUSSION AND CONCLUSIONS

The levels of lighting at which this experiment was conducted did not reach the level of light tolerance when spectacles were worn.

FLUID LENS

RESULTS

There is a progressive drop in tolerance to surround illumination

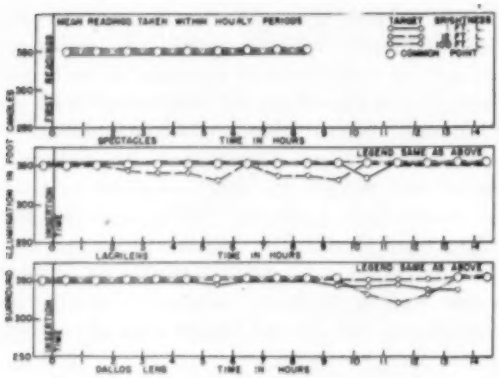

Fig. 17. Tolerance to Surround Illumination.

when fluid lenses are worn, Figure 20. The different levels produced by varying the target brightness had little apparent effect on tolerance to surround illumination. The slight up-swing at the end of the graph is subsequent to the average removal time. The subjects with the poorest tolerance to light were forced to remove the lenses after a shorter wearing time.

Variation of target brightness with zero surround illumination, Figure 16, produced slight variation after the fourth hour. This decrease in tolerance is minimal.

Tests for the tolerance to surround illumination in the hot room revealed a more rapid and marked decline than under normal conditions, Figure 21. The decline in the cold room is not as great, Figure 21. In the low pressure chamber the findings were similar to those in the

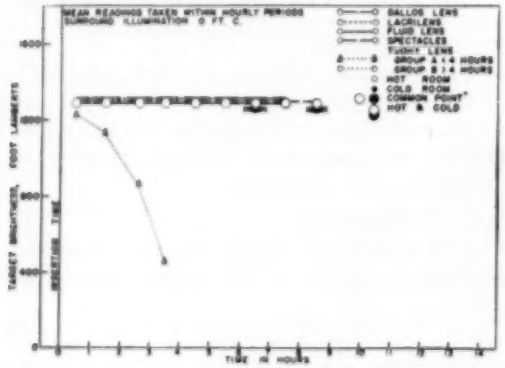

Fig. 18. Tolerance to Target Brightness. Hot and Cold Rooms.

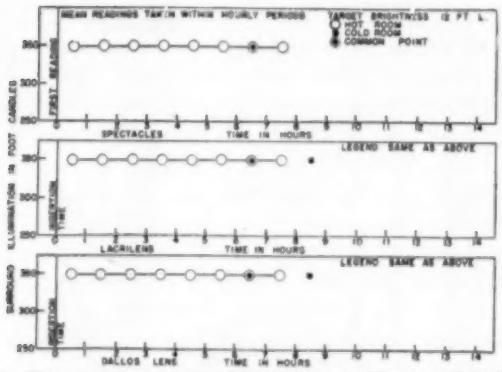

Fig. 19. Tolerance to Surround Illumination in Hot and Cold Rooms.

hot room but slightly more extreme. Target tolerance did not vary appreciably in either hot or cold room, Figure 18, or in the low pressure chamber.

DISCUSSION AND CONCLUSIONS

Photophobia apparently becomes a problem in wearing the fluid lens. From the time of insertion of the fluid lens, there is a progressive decrease in tolerance to surround illumination, while target tolerance is relatively unaffected at the levels tested. It would appear that the two prime causes for this decrease in tolerance are irritation, and veiling glare. The initial cause of photophobia is undoubtedly the mechanical irritation or the irritation of the solution used with the lens. While attempt was made to always use a standard 1½ % solution of sodium bicarbonate, there was some variation from day to day. If subjects

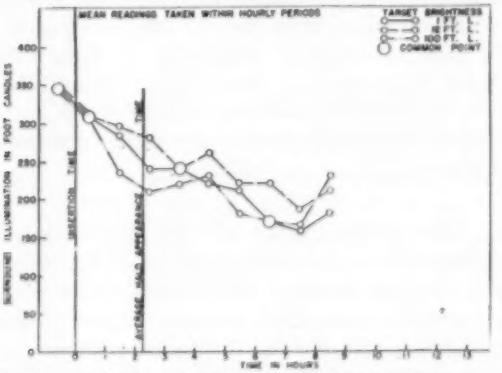

Fig. 20. Fluid Lens. Tolerance to Surround Illumination.

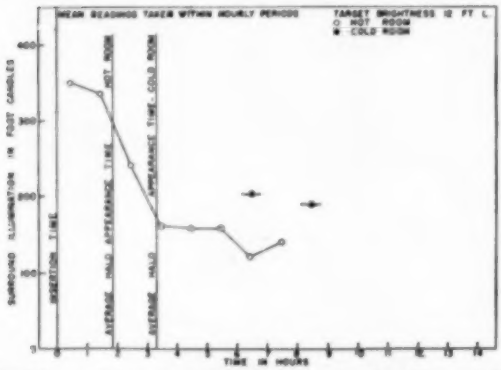
MEAN READINGS TAKEN WITHIN HOURLY PERIODS
TARGET BRIGHTNESS 12 FT. L.
○ HOT ROOM
● COLD ROOM
SURROUND ILLUMINATION IN FOOT CANDLES
INSERTION TIME
AVERAGE HALO APPEARANCE TIME, HOT ROOM
AVERAGE HALO APPEARANCE TIME, COLD ROOM
TIME IN HOURS

Fig. 21. Fluid Lens. Tolerance to Surround Illumination. Hot and Cold Rooms.

were careless and failed to thoroughly cleanse their hands, especially after smoking, they experienced more irritation on inserting the lenses. While the initial and occasional subsequent photophobia is probably associated with the above causes, it does not appear to be the main factor. This is evidenced by the fact that there is little variation initially and target tolerance is virtually unaffected.

Veiling glare, therefore, is probably responsible for a considerable amount of the reduced tolerance to light. Holliday,[7] Harrison,[8] and Crouch,[9] have all discussed the effect of veiling glare upon visual acuity, comfort and light adaptation. It is evident that with the progressive development of corneal clouding, tolerance to surround illumination decreases. The surround, being an extended overall source, produces a marked veiling glare in the presence of corneal haze, which is proportional to the depth of that haze: the small target light source has little effect until corneal haze is extreme. The effect of the veiling glare is somewhat comparable to night driving with a dirty windshield in the presence of oncoming bright lights.

The more marked photophobia evidenced in the hot room is due to increased mechanical irritation and more rapid development of haze.

DALLOS AND LACRILENS

RESULTS

Subjects wearing the Dallos and Lacrilens revealed very little variation in tolerance to surround illumination at the various target levels tested during the fourteen hour experimental runs and under the various climatic and atmospheric extremes, Figures 17 and 19. There was no photophobia recorded in the target tolerance testing under normal and extreme conditions. Figures 16 and 18. The slight

variation seen under normal conditions, Figure 17, with the Dallos lens was due to one subject, the limbal vent, of whose lens occasionally became blocked with mucus after long hours of wear, while that seen with the Lacrilens, Figure 17, was due to one subject who encountered mechanical difficulty with the lens.

DISCUSSION AND CONCLUSIONS

Since the Dallos lens and the Lacrilens were comfortably worn under these test conditions by most subjects and since there was no evidence of corneal haze, mechanical irritation, or veiling glare, photophobia did not develop. The subject who had mechanical irritation with the Lacrilens developed photophobia and the subject whose cornea was improperly aerated because of mucus block when wearing the Dallos lens, developed some corneal haze and subsequent photophobia.

TUOHY

RESULTS

The tests for tolerance to surround illumination with the Tuohy lens revealed marked photophobia in Group A, Figure 22. These

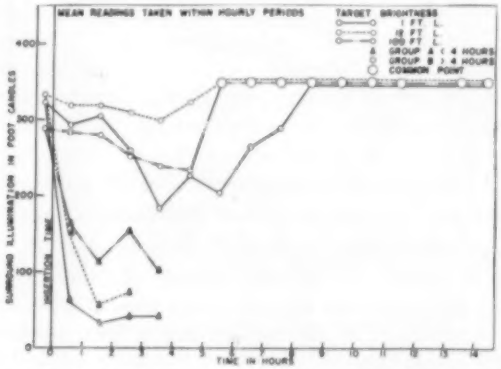

Fig. 22. Tuohy Lens. Tolerance to Surround Illumination.

subjects experienced a great amount of discomfort during this test. It appears from this graph that the tolerance to surround illumination was greater at the higher levels of target brightness. However, examination of individual data did not bear this out. The photophobia increased with wearing time; the form of the graph is simply a result of grouping the individual data. Tolerance to target brightness for Group A was somewhat reduced, but not as greatly as with variation in surround illumination, Figure 16.

In Group B, the initial drop in surround tolerance, Figure 22, is the result of two pheonomena. Some subjects who wore the lenses more than four hours had a gradual progressive decrease in tolerance until the lenses were removed. A few subjects had photophobia until the lenses were removed. A few subjects had photophobia shortly after inserting the lenses: after a few hours this subsided and did not recur throughout the wearing period. There is close association between drops in surround tolerance and reduction in visual acuity. There was a lack of association of tolerance to surround and level of target brightness. There is no variation in target tolerance in Group B, Figure 16.

The findings in the hot room followed a similar pattern, but were accentuated, Figures 18 and 23. The tolerance to surround,

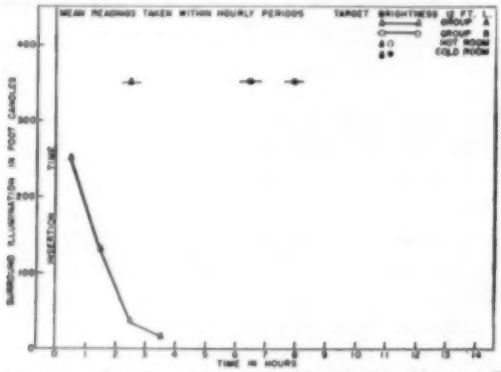

Fig. 23. Tuohy Lens. Tolerance to Surround Illumination, Hot and Cold Rooms.

Figure 23, and target lighting, Figure 18, was good in the cold for both Groups A and B. In the low pressure chamber the findings for Group B were essentially the same as under normal conditions. Group A data was insufficient and inconsistent due to the extreme discomfort of the subjects in this test.

DISCUSSION AND CONCLUSIONS

The tolerance to light with the Tuohy lens was poor. This was essentially due to ocular discomfort which was the result of mechanical irritation or poor individual tolerance to the lens. Stippling of the corneal epithelium was often observed with the slit lamp after removal of these lenses.[1] This may be considered as one cause of the irritation. With rare exception, even the subjects who best tolerated these lenses experienced some discomfort, especially in the first few hours of wearing. These difficulties were exaggerated in the hot room and somewhat

alleviated in the cold room, while low pressure chamber findings were similar to those under normal conditions.

SUMMARY

At the levels tested, photophobia, as experienced in subjects wearing contact lenses, apparently can be secondary to two factors—ocular irritation and corneal clouding. The causes of ocular irritation may be:

1. Improper fitting of lenses, which causes irritation of the cornea, conjunctiva or lids.
2. Chemical irritation from wetting agents, solution, and unclean lenses.
3. Gaseous irritation from smoke, gun-powder fumes, etc.
4. Irritation from dust and other foreign bodies.
5. Individual poor tolerance or inadequate adaptation to contact lenses.

When corneal clouding causes a sufficient scattering of the light rays entering the eye, there results a veiling glare which produces photophobia.

From the results of this study, it seems apparent that the photophobia resulting from ocular irritation is apt to be produced by light from any source. This type of photophobia is usually accompanied by varying degrees of lacrimation, pain, blepharo-spasm, and often accommodative spasm.[11, 12, 13] The photophobia, secondary to veiling glare at the levels tested and in the presence of the degree of corneal clouding that was found, was seldom severe enough to produce lacrimation, etc. Photophobia was especially prevalent in the presence of an extended light source which induced increased scattering. It was often difficult to separate the two primary causes of photophobia and to determine the relative effect of each. In the presence of photophobia, when corneal haze was not in evidence, it must be assumed that ocular irritation was the cause.

Few subjects wearing the fluid lens experienced any significant amount of ocular irritation and yet manifested considerable photophobia of a progressive nature. This intolerance to light was therefore probably secondary to corneal clouding and the resultant veiling glare.

The results with the Tuohy lens, on the other hand, must be due to ocular irritation since no corneal haze developed.

At the levels of light at which the lenses were tested, photophobia did not exist with spectacles, Dallos lens, and Lacrilens. Therefore, it can be assumed that corneal haze and ocular irritation were minimal with these lenses, but were quite evident with the Tuohy and the fluid lenses.

CONCLUSIONS

In reviewing the results of the testing no complete or final judgment can be passed on any of the lenses since only two phases of an extensive study[1] are discussed in this paper. However, visual acuity and photophobia are important criteria in any evaluation of visual aids.

From the foregoing material, certain general conclusions may be drawn. It is evident that at the levels of lighting used in these experiments primary photophobia should not have existed. Where it did exist, it could be traced to some contributing factor. Any of several causes of ocular irritation result in photophobia with contact lenses, and a prominent cause of irritation is poor fit or poor individual tolerance to a given type of lens. From inspection of the graphs, it is seen that with poor tolerance or fit, a marked effect takes place. Not only does the individual become overly sensitive to very low levels of illumination, but he experiences difficulty in visual performance. In the case of the Tuohy corneal lens, because of its poor showing in these phases of the experiments it was not evaluated for visual acuity or photophobia since fitting might have been the cause of the difficulties. In the few cases where ocular irritation did not exist, these lenses provided satisfactory vision and tolerance to light.

Another difficulty observed occurred when corneal clouding existed: here a marked decrease in visual acuity and tolerance to light was evident. In view of the extent of these changes, it might be noted that a lens which induces corneal haze, as was indicated in those experiments with the fluid lens, is unacceptable for general use except when other advantages override these considerations.

One may conclude that spectacles, the Dallos lens and the Lacrilens provide equivalent, adequate vision and tolerance to light under the conditions tested. Further, on a comparative basis, it can be assumed that the individual wearing these lenses is not disturbed by any marked ocular discomfort or irritation and corneal clouding does not take place to any appreciable degree.

Photophobia and hazy vision have long been associated with contact lenses by the layman, but in view of the many recent advancements in design which have overcome these difficulties, it is foreseeable that contact lenses will have greater public acceptance and will be more readily prescribed.

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SPECIAL REPORT

SOME ISSUES IN SCHOOL VISION SCREENING*

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I. THE NEED FOR VISUAL CARE IN THE SCHOOL POPULATION

To begin this discussion, it seems desirable to review briefly some notes on the magnitude of the school vision health problem.

Our major concern is with the children of elementary and secondary school age, those who are roughly between the ages of 5 and 17 years. At present, there are about 30 million of them. In 1960, the number will be close to 40 million. These children constitute a large and rapidly growing portion of our population.

Statistics on the visual health of the school population are not very extensive, but the information available is worthy of careful consideration. The best evidence comes from studies in which ophthalmic practitioners have examined rather large numbers of school children. O'Shea[3] classified 37 per cent of his subjects as needing professional attention. Scobee[4] found that, in order not to miss any individual who might need visual care, 46 per cent should have complete examinations: the findings of the complete examinations, however,

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indicated that only 26 per cent actually needed care. Hirsch[2] has reported that 25 per cent of the children examined need visual care. From these data one might estimate roughly that one in four, or approximately 7½ million school children, need visual care.

It is very difficult to estimate the number of children who receive the visual care needed. Ordinary sampling errors are complicated by geographic and socio-economic factors. However, we do have some data for children in grades 1 through 8. In O'Shea's study,[3] 11.2 per cent had been examined and given a prescription at some time. Hirsch[2] found that only 5.6 per cent were under care; this represented only 22 per cent of those found to need care. By contrast, in a community close to Cleveland, 24.6 per cent were found to be wearing corrections of some kind.[1] These figures do not allow even rough estimates of how many children have not received the visual care needed, but it is safe to assume that the number is large for the country as a whole.

Although limited in scope, the available data indicate that the visual health needs of the school population are large and that, in general, these needs are not being met adequately. The issues in school vision screening arise from consideration of methods by which vision health programs might be improved and more adequate visual care provided for school children.

II. METHODS FOR PROVIDING MORE ADEQUATE VISUAL CARE

There is only one method by which we can be certain that all children needing visual care will have an opportunity to obtain it. This method would require that each child in the school age population have, periodically, a complete eye examination by an ophthalmic practitioner. Unfortunately, few parents are prepared to take this step and the number of practitioners available does not appear sufficient for the undertaking.

At the present time, there are approximately twenty-five thousand ophthalmologists and optometrists in the United States. If these practitioners undertook in any one year to give complete eye examinations to 30 or more million children, they would encounter a task of tremendous proportion. Furthermore, about three-quarters of the time required would be spent examining children who do not need visual care. In this respect, the procedure would seem to involve a relatively inefficient use of the professional services available to us; in addition, it would probably interfere seriously with the professional services rendered to other portions of our population. A program of complete periodic eye examinations does not seem practicable on a

national scale. For this reason, we have a screening problem. The problems in school vision screening would not arise if a program of complete eye examinations were feasible.

The purpose of screening is to conserve and utilize to best advantage the services of our practitioners by sending to them for complete examinations only those children who are most likely to need visual care. In this way, we can hope to reduce the time, and the money, required for the examination of children who do not need visual care and, at the same time, to make it possible for the practitioners to function efficiently in providing visual care where needed.

The best possible screening programs would be those in which ophthalmic practitioners do the testing. If they could make abbreviated examinations, using clinical tests and applying their professional judgment regarding the need for visual care, screening might be almost as effective as complete examinations. Unfortunately, periodic screening of 30 million children scattered among 200,000 school plants, would seem to present a formidable task to 25,000 practitioners. It appears impossible to formulate a plan whereby ophthalmic practitioners could find time for this activity, or whereby the schools could pay for their services. Again, as in the case of complete eye examinations, there does not seem to be any practicable program for screening examinations by practitioners that can solve the school vision health problem on a national scale.

Where examinations by practitioners cannot be provided, it is necessary to seek other means by which visual care might be obtained for the children who require it. The most promising approach would appear to be a professionally approved screening program enabling school personnel to identify and refer for complete examination the children likely to need care. When compared with examinations by practitioners, this method has obvious limitations. Nevertheless, it constitutes a most promising approach, one through which we can hope to attack the school vision problem on a large scale.

III. ERRORS IN SCREENING

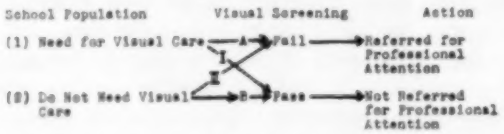
Essentially, visual screening is an effort to predict the outcomes of complete examinations on the basis of relatively limited information. Diagrammatically, this can be expressed as follows:

Screening Routine		Predicted Outcome of Complete Examination
Fail	⟶	Need Visual Care
Pass	⟶	Do Not Need Visual Care

All children either pass or fail the screening routine. For those

who fail, it is predicted that visual care is needed and a complete visual examination is recommended. For those who pass, it is predicted that visual care is not needed; consequently, no referral is made.

This kind of prediction is not infallible. For the purpose of discussing the errors that occur, we may refer to another diagram:



I, Errors of Under-referral. II, Errors of Over-referral

On the left, the School Population is indicated as falling in two categories, (1) those needing visual care, and (2) those not needing visual care. It is the intent of the screening program that all children in category (1), needing visual care, shall fail the test and be referred for a complete examination (Arrow A) and that all children in category (2), not needing visual care, shall pass the screening test and not be referred for a complete examination, (Arrow B). This is the manner in which a theoretically perfect screening procedure would operate. Screening is less than perfect, however, and it is important to understand the nature of the errors that occur.

One kind of error is represented by Arrow I. It indicates that some children needing visual care may pass the screening and not be referred for professional attention. These "Errors of Under-Referral" can occur (a) when a visual deficiency is such that it can be detected only in a complete eye examination, (b) when tests that might reveal certain deficiencies are not used, or (c) when some test is applied with relatively low standards for passing.

Another kind of error is represented by Arrow II. It indicates that some children, not needing visual care, may fail the screening and be referred for professional attention. These "Errors of Over-Referral" can occur (a) when a screening test or observation does not correspond very closely with the need for visual care, or (b) when tests are applied with relatively high standards for passing. (Both kinds of error can also occur by chance. There are numerous uncontrollable factors in school vision screening procedures. It is highly desirable, however, that the testing routine and the test behavior of children and examiners be standardized within practicable limits to reduce the frequency of these chance errors.)

It is interesting to consider how one or the other kind of error might be reduced. The frequency of errors of under-referral (Arrow I)

might be reduced by using more tests and raising the standards for passing the tests used. This would increase the difficulty of the screening routine; more children who need care would fail and be referred for complete examinations.

Although the errors of under-referral could be reduced in this manner, such a procedure cannot be adopted without restriction. It is necessary to consider what possible effect it might have on the errors of over-referral (Arrow II).

When a screening routine is changed in the direction which results in the failure of more children in category (1), needing visual care, it is highly probable that more children in category (2), not needing visual care, will also fail the test and be referred for complete examinations. Thus, as we reduce errors of under-referral, we tend to increase errors of over-referral.

This procedure may be reversed to consider the reduction of errors of over-referral. Using fewer tests and lowering the standards for passing the tests used, we could make it easier to pass the screening routine. More children in category (2) would pass. At the same time, unfortunately, more children in category (1), needing visual care, would also pass. Thus, as we reduce the errors of over-referral, we tend to increase the errors of under-referral.

Perhaps this can be clarified further by considering the extreme situation in which we undertake to eliminate entirely one or the other kind of error. For example, if every child in categories (1) and (2) fails the screening or is referred anyway, errors of under-referral (Arrow I) are impossible. Eliminating in this way all errors of under-referral, the errors of over-referral (Arrow II) are maximized. It seems unnecessary to point out that, to eliminate errors of over-referral, we must pass all children and make no referrals, maximizing errors of under-referral.

Here we have the dilemma of those engaged in screening. Efforts to decrease one kind of error tend to increase the other kind. In school vision screening, therefore, it is unwise to undertake simply to reduce or eliminate one kind of error. Our efforts should be directed toward keeping both errors of under-referral and errors of over-referral within practical limits of tolerance, consistent with the desired outcomes of screening. It seems to me that progress is very slow if we concern ourselves with one kind of error, ignoring the other.

Not long ago, I heard a report on a school vision screening program in which it was emphasized that practically all the children who were failed and referred for professional attention were found to

need visual care. Errors of over-referral were very rare. It seemed to me unfortunate to have this low over-referral rate interpreted as entirely good, especially when no reference was made to errors of under-referral. It is good to know that most children failing the screening test came from group (1), those needing visual care, and that very few came from group (2), those not needing care. On the other hand, one should not ignore the question of how many of those passing the screening test came from group (1), children needing visual care.

Unfortunately, errors of over-referral have received the greatest attention. They are easily detected because the children involved receive complete examinations and information that they do not need visual care is reported frequently. In ordinary screening practices, the children involved in errors of under-referral are not identified in any systematic manner; data concerning them are not often reported. It seems to me, however, that both kinds of screening error must enter into any thorough evaluation of the effectiveness of school vision screening practices.

IV. CHARACTERISTICS OF VISUAL HEALTH PROGRAMS OF IMPORTANCE TO THE SCHOOLS

Educators cannot fail to recognize the importance of good vision to individuals, both in school and in later occupational achievements. A number of states have laws or regulations regarding certain minimum practices in vision testing. Where screening practices are established, they very frequently go beyond these minimum standards. It seems to me that schools are prepared to take every feasible step to improve visual health programs, but it is not easy to identify the best methods to follow.

The characteristics of visual screening programs of special importance to schools must be considered among other issues. Three items can be noted here.

1. *Screening must be efficient.* Although 11 or 12 years are allowed for elementary and secondary education, the competition for school time is rather great. It is always desirable to increase the time allotted to social studies, science, health education, physical education, art and music. Since all areas of the curriculum could be expanded profitably, the school's schedule is developed through a series of compromises, and rigidly followed allotments of time must be made. Despite this scheduling, the routine at school is subject to considerable variation. Occasions for special exercises are very common. Current events like the inauguration of a new President, and many holidays like Thanksgiving, Christmas, Washington's Birthday, must be observed. In addition, there are weeks during which special emphasis is

placed on certain goals of education. We have, for example, Safety Week, Fire Prevention Week, Brotherhood Week, Thrift Week, Be Kind to Animals Week, Health Week, and Save Your Vision Week. In addition to engaging in all of these worth-while activities to educate the whole child, the schools must also continue to be a little old-fashioned and teach all children to read, write, do arithmetic, and even to do problems in arithmetic.

Considering the fullness of the curriculum, it is important that visual screening procedures be designed to consume a minimum of school time. Very frequently, when the question of school vision screening arises, it is suggested that a very complete vision testing program be established. This is by no means harmful, but it is time consuming and relatively inefficient. The purpose of screening is not to collect a great deal of information on the vision of each child; it is to identify and to refer for professional attention the children who need visual care. Procedures designed to do the screening job alone can be made far more efficient than generalized vision tests.

2. *Screening practices must be authoritative.* A school administrator does not hesitate to act when it is clear that some practical vision screening program is the best course to follow. On the other hand, he has difficulty in making a decision in areas where opinions are uncertain or conflicting, and especially where there are signs of controversy. Unfortunately, the complex nature of visual functions results in minor differences of opinion regarding desirable screening practices and the educator is not in a position to make an independent evaluation of the questions arising.

The school administrator has broad obligations to children, parents and the community as a whole. In visual screening, as in many other school activities, he bears the burden of general responsibility. He receives the letter from the irate parent who missed a day of work in order to have a child examined by a practitioner, only to find that no visual care was indicated. Similarly, the letters reporting that the screening program did not detect a visual deficiency recently encountered are addressed to him. This more or less routine burden is accepted readily if the procedures being followed are in the best interests of the children and authorized or supported by the Ophthalmic professions.

It is very natural for school people to be conservative. Perhaps, for this reason, the Snellen Chart testing routine, with rather easy standards for passing, has been very durable. Everyone seems to agree that this minimum screening, at least, is desirable. It is far better than no screening program, but it has important limitations. Frequently the

test conditions are not standardized and the findings tend to be unreliable. Furthermore, the distance acuity test functions mainly to identify the children with myopia and/or astigmatism; it makes no check on other important visual deficiencies. Despite these limitations, the schools are likely to continue this kind of minimum screening practice in the absence of authoritative support for more detailed testing.

School vision screening serves only to refer for professional attention those children who appear to need visual care. The ophthalmic practitioner's findings and actions are the criteria by which screening practices must be evaluated. The schools must, therefore, turn to the practitioners for guidance and authoritative support for the screening program.

3. *The education of visually handicapped children.* Another area in which school people need the help of the ophthalmic practitioner concerns visually handicapped children. In some instances, adequate visual care does not terminate in the practitioner's office; some aspects of the visual problem need attention both at home and in school.

In the larger communities, children with extreme visual handicaps are cared for in sight-saving classes. There are, however, some seriously handicapped children who do not attend schools with sight-saving classes and others who, although handicapped, do not qualify for sight-saving classes. These children need special consideration and it is important to have the guidance of the ophthalmic practitioners.

With very rare exceptions, the children who receive visual care in the form of surgery, training or corrections have improved vision. In some instances, however, this improved vision is not such that the children can compete adequately with others whose vision is good, with or without visual care. Consequently, it is not always correct to assume that, after a child has had visual care, no appreciable handicap remains. It is highly desirable, therefore, that practitioners note for the schools the relevant information concerning the visual handicaps of some children, and suggest measures which might facilitate effective seeing. These notes or reports are necessary to assist school personnel in making reasonable provisions for the special needs of some handicapped children.

V. THE ROLE OF THE OPHTHALMIC PRACTITIONERS

The role of the Ophthalmic Professions in the school vision screening area has already been discussed in preceding sections of this paper.

With regard to possible solutions to the school vision health problem, it has been indicated that the best solution would be for each school child to receive, periodically, a practitioner's complete eye exam-

ination. Where this is not practicable, it was noted that the next best approach would be one in which practitioners conduct screening examinations in the schools. Unfortunately, neither complete nor screening examinations by ophthalmic practitioners seem to offer a practicable solution to the school vision problem on a national scale.

The most promising large scale visual health program appears to be one in which screening routines are carried out in the schools. Here, again, the practitioner must play a crucial role. It is necessary that he advise and cooperate with school authorities in the development of effective screening procedures. The schools must look to the ophthalmic professions not only for authoritative support for screening practices, but also for important information regarding handicapped children.

It seems to me that a random sampling of professional opinion would reveal many differences concerning what would constitute a sound school vision screening program. Many of the differences can be reconciled or eliminated for all practical purposes by discussing the issues in meetings and conferences. It seems certain that, despite the appearance of rather wide differences, there are levels of general agreement which should be clarified as soon as possible. School people would be pleased to have authoritative reports on these areas of agreement; too often, they receive no reports or only miscellaneous notes which they cannot evaluate.

The most satisfactory technique for clarifying the questions at hand would require our having detailed information concerning school vision health problems. Once the necessary facts are gathered by carefully planned research, it seems very unlikely that there will be any considerable difference of opinion regarding school vision screening. In all probability, what appear to be important differences of opinion exist only because we do not have the basic data needed to evaluate clearly the issues at hand.

VI. THE NEED FOR APPLIED RESEARCH

It is relatively easy to talk about issues in school vision screening. The determination of the best solutions to the problems encountered presents a far more difficult task. Our basic need is for applied research on the effectiveness of various screening procedures. The studies should be the result of the cooperative efforts of the schools and the ophthalmic practitioners.

At the risk of noting the obvious, a few specifications for items in school vision screening tests may be listed for consideration:

1. The measurements must be reliable. This characteristic can be improved by selecting tests carefully, standardizing the

conditions of testing, and reducing factors which introduce examiner variables.

2. The measurements made must be related to the need for visual care as revealed by complete eye examinations. This relationship is the predictive value of a test.
3. The critical point adopted in each measure to distinguish between children passing and children failing must be established with reference to both the predictive value of the test, and the necessary compromise between errors of under-referral and errors of over-referral.

Similar evaluations need to be made for factors like observations of behavior and visual symptoms that might also be used to identify children in need of visual care.

When it can be established that certain measures with particular critical points for passing or failing are appropriate, a great deal can be done to facilitate the school vision screening task. At the present time, however, there is need for carefully planned research to provide the information with which to identify practicable, effective, and efficient school vision screening procedures.

In discussing issues in school vision screening, an effort has been made to call attention to some problems and to indicate the kind of research needed to solve these problems. It is not suggested, however, that we wait out the relatively slow progress of research. An examination of school vision health programs indicates that many improvements can be made now. Applying what may be referred to as the "educated guess," some very significant gains can be made in revising for the better our current school vision screening practices and in providing more adequate visual care for school children.

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AN OVERALL PLAN REQUIRED TO COMBAT THE "QUICKIE" REFRACTIONIST

A gloomy picture of the current activities of "quickie" refractionists has recently been presented by Wahl[1] and by Kohn.[2] Since they are American Optometric Association officials. their reports have been widely read and discussed by optometrists. The reports cover some aspects of the problem thoroughly—the financial successes achieved by some "quickie" refractionists and the slipshod work they do. The reports do not mention, however, the problems and failures, and un-

[1]James F. Wahl. Creeping Death. Journal of the American Optometric Association. 24.4.1953.
[2]Harold Kohn. Optical Plans. Journal of the American Optometric Association. 24.5.1953 and 24.6.1954.

fortunately present no realistic concrete suggestions for eliminating this nefarious type of practice.

In considering the "quickie" refractionist we must realize that among those who enter this field of commercial optometry, the percentage of failure is high. Many of these cut rate optical parlors fail to catch on, and fold quickly, leaving behind a large loss in dissipated capital investment. Also, contracts with unions and industry are always at the mercy of others who will further reduce the costs of materials and service to secure these contracts. Commercial optical practice is a dog-eat-dog business, and the lives of many of these outfits are short compared to the life time of steady practice and real service of the ethical optometrist.

In addition, the commercial "quickie" refractionist is usually faced with very high overhead in relation to the gross volume of business he must do to survive. He has high rent, large advertising appropriation, and he must pay high salaries. His advertising is not always productive, but he must continue to advertise to survive since he cannot count upon the referrals by satisfied patients which build the professional practice. His turnover of professional help is large since no optometrist or physician likes to continually apologize to his friends for the manner and surroundings in which he practices. This turnover of optometrists or physicians is always most costly to the proprietor.

Optometrists, too, must realize that a goodly number of patients who patronize these "quickie" optical parlors are not lured away from professionally practising optometrists or ophthalmologists. To be sure, some are, but usually not for long. Many persons, who respond to the price appeal of the "quickie" refractionist, have heretofore been served by the glazed goods or mail order firms, or they are persons who have been using cast off glasses of others. These individuals rarely receive adequate medical or dental care either. Some are not health conscious, and some come from exteremely low income groups where, even with proffered credit terms, the individual fees and charges of profession men seem out of their reach regardless of desire or intent. [This could be rectified by private or public clinics.] In short, the "quickie" refractionist has his problems. His lot is not always a happy one, despite the evidence of substantial fortunes made by a small minority of those in this field.

Wahl and Kohn in their reports, strongly urge more and more education to combat the "quickie" refractionist. They call upon all optometrists to subscribe to the Optometric Extension Program, as a step in combating this form of commercial practice. The writer has

no quarrel with those who wish to subscribe to the O. E. P., but a subscription to the monthly educational service of the O. E. P. will not solve the problem under consideration, any more than a subscription would to any scientific journal. This certainly is not the answer.

Wahl and Kohn also suggest better public relations and the exclusive use of first quality materials. These good suggestions are all right as far as they go—but they do not reach the heart of the matter.

The "quickie" refractionist is bad for the public's visual well-being. He will disappear only when he is driven out by the opinion of an enlightened public, by the enforcement of existing legislation, and by the enactment and enforcement of further stringent legislation curtailing his activities. To achieve this we need a comprehensive, well-worked-out plan or schedule conceived and carefully thought out by the A. O. A. This can then be passed down to and implemented by the State Associations according to the specific problems presented in each State. This national program must take into account all facets of the problem.

Only the A. O. A. can hold the necessary conferences with the publishers' association, the American Bar Association, ophthalmological groups, the A. M. A., the national clearing house for Better Business Bureaus, and leading administrative people in the field of social work and government health programs.

These conferences would serve the dual purpose of obtaining needed advice in handling the problem and of molding public opinion by making these persons and agencies aware of the harm done by the "quickie" refractionist and of the desire of organized optometry to combat him.

As part of the overall national plan, model legislation should be drafted and made available to State groups needing such help. These groups would be charged with the work of passing such legislation, but the overall planning and direction must come from the A. O. A. if it intends to serve optometry and the public as they should be served.

Centralized organization and direction is needed now more than ever before to put into effect a well rounded plan aimed at protecting the public. Such a plan will be acceptable at the State level: there is already a demand for this from many places. The inequities of the current situation demand that this action be taken so that all segments of the public may be served properly. There is obviously much to do.

CAREL C. KOCH

TRANSACTIONS OF THE AMERICAN ACADEMY OF OPTOMETRY

A department devoted to announcements, reports, appointments, organization data, news, professional problems and ideals, as these relate to the Academy.

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CORRESPONDENCE

NEED FOR THE UNDERSTANDING OF EACH OTHER'S PROBLEMS

To the Editor:

Thank you very much for your very interesting reply to my letter. Considering the imminence of the Academy meeting, I was rather overwhelmed with the length and thoughtfulness of your missive.

I appreciated your sending me the article *"Is There a Pattern?"*, from GUILDCRAFT. Although I had already read it, I nevertheless re-read it, together with your article, *"Problems with Dispensing Opticians,"* and your editorial in the November issue of the Archives. When I had finished I must confess that my heart sank, for I see little evidence of good-will on the part of either ourselves or the opticians. (I am not referring to your own views, but rather to the viewpoint of organized optometry as you portray it.) Neither we nor they seem capable of making even a token effort to understand the opposing point of view, and it seems hard to believe that either opticianry or optometry is genuinely interested primarily in the public good.

It would, of course, be easy to criticize much of Carpenter's article. It is, if you like, biased, misleading, exaggerated, unyielding, and you can probably add many more adjectives. But what disturbs me is that it also contains many very valid points. And it is these valid points that should certainly be of equal concern to optometrists. For instance, it seems to me that this statement that ". . . until (optometry) can control the aggressiveness of its local members, it should cease asking for additional privileges for these same locals, at the national level," is most telling, and should be taken very much to heart. Recently I brought up the matter of filling ophthalmologists' prescriptions at our local society meeting, and was very much surprised to hear members whom I felt sure would not fill a prescription, openly admit that they would and did. They gave various explanations for their doing so, but the important thing is that they did fill prescriptions. I wonder just how prevalent this abuse is.

Were I an optician I would feel particularly chagrined at optometry's consistent opposition to ophthalmic dispensing legislation. Optometry suffered from similar obstructionism at the hands of the medical profession when it was seeking optometric legislation. Having triumphed, it is most unseemly that we should now, with such determined dexterity, turn about and adopt the very attitude to which we so rightly objected when it was used against us.

In your November editorial you wrote that "Optometry contends that dispensing opticians have no place on a 'professional committee' as their work is non-professional in character and scope, and is conducted solely as a business with an almost complete disregard for professional ethics." (Again I realize that these may not be your views, but those of the profession.) When I read this I was immediately struck by the fact that, 25 years ago, one could have written the same sentence and applied it to optometrists merely by changing the opening words to "Medicine contends that optometrists . . . etc." Indeed there are some medical men who still have this attitude. Surely it would be better simply to omit the word "Professional" from the name of the committee, and to retain the opticians. To have the composition of the committee determined by the name of the committee is letting the tail wag the dog with a vengeance.

If ophthalmic dispensers wish to make themselves "professional" there is theoretically no reason why they should not charge a flat fee for dispensing, plus cost of materials, in the manner in which *some* optometrists do. If it be suggested that optometry would withdraw its objections to licensing of dispensers *after* opticianry "cleaned house," optometrists should remember—and never forget—that licensing largely *preceded* professionalism in optometry. The latter process is still far from complete. Optometry fought and won its licensing laws against the opposition of *organized* medicine. *After this* it turned around and started to clean house. Not before. In this, too, organized medicine did not help us, although many individual medical men did so most generously. Shall we now, in our turn, inflict this same hostile, destructive, repressive attitude on the dispensers? To do so were to be like the newly-rich who harbours a profound contempt, not only for poverty, *but also for the poor*.

Perhaps I was remiss in my letter in not paying more tribute to your own continuing good works, now and in the past, in reminding optometry of its deficiencies. And I suppose one wearies of continually playing the same tune. Yet it seems to me that the same tune must be played over and over again as long as it contains any truth. If we don't, our critics surely will. Let me put it this way. Suppose the reverse situation. Suppose a prominent, very sincere leader of opticianry had written an article accusing optometry of certain abuses—accusations that contained undoubted merit. And suppose further that this same optician had spent a large part of his life trying to stamp out opticianry's own shortcomings. Would it not nevertheless be true that most rank and file *optometrists* who read such an article would be ignorant of

the opticians' fine record. They would tend to judge the article *by the article itself*. How else could they judge it? And would it not also be true that such an article, for all its undoubted validity *could not but fail* to achieve the effect desired by its author, and would more likely have a negative value.

Little can be done to ameliorate the relationship between the two groups without an earnest desire to understand each other's problems, and an awareness by each group of its own glaring imperfections. If optometry were courageous enough to take this attitude, it might be asked how we could be sure that opticianry will reciprocate. We cannot be. Certainly we cannot expect them to change towards us by adopting an implacable attitude towards them. Proposing the exclusion of opticians from the National Interprofessional Committee on Eye Care is hardly the diplomatic way to improve relations—if we really do wish to improve relations. Rather, it would tend to perpetuate the guilt. Hostility has a tendency to get hostility. We cannot be sure that good will, and a helping hand, coupled with a frank admission of our own human shortcomings is the right road. But we do know, or surely ought to know, that the present path leads only into the wilderness.

You are a very busy man. I, as you can plainly see from the length of this letter, am less busy. So please do not feel obligated to prolong this correspondence if it unduly encroaches on what must be your very limited time. My only excuse for this letter is that you invited my reactions to the material you sent me. I do not know how representative my own viewpoint is. Nor, do I know how closely the viewpoint of optometry's representatives are aligned with those of the rank and file. You have certainly given careful consideration to my previous letter—perhaps more than it merited—as well as passing it on to Dr. Morgan, and whether you agree with my position or not I would like to thank you for the open-minded way in which you have listened to it.

ASHLEY KING, O.D.

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IMPLEMENTATION OF A. O. A. RESOLUTION CALLED FOR

To the Editor:

I have followed with interest editor Koch's excellent article *"Problem with Dispensing Opticians"* and the discussion ensuing. In the October 1953 issue of GUILDCRAFT, H. B. Carpenter replied to Koch's article with a report entitled *"Is there a Pattern?"* There ap-

peared in the December issue of this Journal two commentaries on this reply.

I consider Dr. Freeman's editorial and Dr. Springer's letter, which constitute the two commentaries mentioned above, to cover the Guild reply quite well except for that portion upon which I intend to enlarge, later on in this letter. It was gratifying to note the forbearance with which these authors dealt with the subject, despite all provocation in Carpenter's article. Facts were presented and inferences noted. Freeman's closing paragraph seemed especially pertinent.

For my part I should like to make a few points with regards to Carpenter's attack on optometry for its alleged neglect or inability to enforce the resolution passed by the A. O. A. which declares that it is the policy of the A. O. A. not to fill prescriptions originating with any other practitioner. Unfortunately for us, although much of Carpenter's article was disagreeable in tone and intent (principally he imputes a total lack of sincerity to optometry both national and local in its quest for harmony in the eye care field) there is nevertheless the thundering voice of truth in his assertions concerning this resolution. (The reader is here referred to p. 658 in the December issue of this Journal where Freeman quotes Carpenter's remarks to the resolution in question.) If 90 per cent of the optometrists are not willing to fill prescriptions of other practitioners, the number who will is still, undoubtedly, very high. And here we have a rallying ground for the whole of opticianry, and rightly so, for how can we ask them to stop their unethical damning of our profession by faint praise or worse while we at the same time pay only lip service to a resolution passed by our national organization, which if followed scrupulously would go far towards eliminating discord between optometry and opticianry. Because of this, our position in this part of the controversy at this time, seems both arrogant and untenable.

I am of the opinion that opticianry as a whole will find it possible to comply with the suggestion so ably set forth in Koch's article *after* we have complied in essence, as well as acclaimation, with the previously mentioned A. O. A. resolution. This resolution obviously needs implementation both by the state societies and the national organization. The majority of optometrists will find it within themselves to comply with its provisions, once they understand the wisdom of so doing. When this has been accomplished our bargaining position shall have been vastly improved.

A. E. GUIDARELLI, O.D.

105½ MAIN STREET,
PENN YAN, NEW YORK.

A SUGGESTION TO RECENT GRADUATES

To the Editor:

In May of 1953, I received my diploma from the Columbia University School of Optometry. As I sat through the graduation I looked back over the years and thought of the remarks made about optometry by both my fellow students and lay individuals. Owing to the fact that Columbia is situated in New York City a great many disturbing influences surround the profession. I feel that I do not have to go into a description of some of the remarks that were made, for when we face the facts we find that a great many of the statements lead one to think of why an investment of well over $5,000, including home expenses, books, tuition, etc., was made if many of the students felt that to be successful in optometry they would have to "push glasses." This disturbed me for I felt that optometry is the future profession; the only thing that it lacked was the strength of conviction that is sorely needed by many practitioners in the field.

I collected my thoughts and analyzed the situation. The main reason many graduates fall into commercialism the moment they graduate and pass their state boards is the lack of immediate finances. The attainment of financial security is a proper end; however the means to this end are warped when one enters a commercial practice. Commercialism is detrimental to those practicing professionally and to professional minded students.

After all, with employment the way it is, plus a college background, there must be many situations in the field of optics that will afford one a decent salary and let him go home with a clear conscience without "prostituting" himself in some commercial organization. Therefore I inquired at my local employment office for a job in the line of optics. In one day I received a position as an optical engineer with a research company at a salary not many would receive as a commercial optometrist. Yes, it was difficult at first but I am now integrated into the field.

Let us look at the advantages attained: (1) good salary; (2) clear conscience; (3) ample income so that now I may open my office and keep my same job. The office at night and Saturdays and my job during the day. (4) Prestige (which in actuality means being able to walk with your head high).

There are many other advantages but above all there is the feeling that I am not impeding those that believe in optometry, and thus am directly bettering myself. In closing let me inject one last thought:

If you are financially unable to open up your office, do not commercialize yourself for in the long run you are the sufferer.

E. A. LLOYD, O.D.

1664 HOE AVENUE
NEW YORK 60, N. Y.

MANUAL OF OCULAR TESTS AND REQUIREMENTS

To the Editor:

Thank you very much for the favorable comment given me by Miss Parkins in her review of the *Manual of Ocular Tests and Requirements*, in the November issue of the Journal. Too much credit is given to me in this review.

Other Fellows of the Academy made substantial contributions. The original compilation was done by Dr. Richard M. Hall of Cleveland, and Dr. Charles Sheard of Rochester. The first revision was done by Dr. Henry Hofstetter now of Bloomington, Indiana. I did only the current revision. I feel that these men should have some public recognition for the important contribution they gave to this work.

H. WARD EWALT, O.D.

8001 JENKINS ARCADE
PITTSBURGH 22, PENNA.

To the Editor:

Just to keep the record straight, I would like to call your attention to the review by Terry Judith Parkins, page 587, November issue of the Journal.

This material was not originally compiled by Dr. Ewalt, but rather by Sheard and Hall—then chairman and secretary (respectively) of the A. O. A. Council on Education.

The idea was the brain child of Dr. Don R. Paine, who originally intended it to be an Academy project: however with one thing or another, the war, lack of funds, etc. . . ., the actual work was done by the Council early in 1942, and was first published by the American Optometric Association that year.

Later, the date now slips my mind, Dr. Henry W. Hofstetter was engaged to bring the material up to date—this became the second edition. It is now in its third edition, and much of the credit for this later work belongs to Dr. H. Ward Ewalt, I believe.

RICHARD M. HALL, O.D.

419 GUARDIAN BLDG.
CLEVELAND 14, OHIO

CURRENT COMMENTS

Terry Judith Parkins
Editorial Assistant

Optometrists will confer a favor by sending news items of general interest for this department, such as relate to new instruments, clinical techniques, education, visual health and optometric legislation and organization.

THE "EYE SPECIALIST" BY ERIK CRIPPS

A script for a new optometric film was presented at the recent A. O. A. conference on public relations at St. Louis. It is very good and we hope the picture will be run and soon released. In the proposed film the setting is the refracting room of an optometrist—Dr. Cliff Carey—and shows his experiences with several patients. His discussions with and advice to these patients enable the producer to review the high points of eye care and the need for periodic and thorough eye examinations and refractions.

To enable the film to continue without too many cut-backs and changes in locale, patients wander in and out of the refracting room while an examination is in progress, but this no doubt helps to speed up the action without seriously interfering with the authenticity of the sequence itself. In all, the producer, Erik Cripps, seems to have hit upon a satisfactory vehicle, that in this sort of thing is difficult to do with realism and conviction.

We did wonder somewhat at the title of the film, which is "Eye Specialist." As this is an optometric film to be produced for the A. O. A., why not call it "The Optometrist," but that is a minor matter. The important thing is not the title but the film itself and getting it shown to millions of Americans who will enjoy it and become more eye conscious at the same time.

COURSE IN GRAPHICAL ANALYSIS AT LOS ANGELES COLLEGE

The Los Angeles College of Optometry has announced a new graduate course for practicing optometrists. This course, deals with the graphical anlysis of optometric findings. The material is mailed direct to the office of the optometrist and when one section is completed and approved the next is sent to the doctor.

The course consists of fifty consecutive graded lessons designed to familiarize the practicing optometrist with the most recent scientific approach to an analysis of optometric findings. The course systematically develops the background for accurate plotting of binocular findings. This leads to the establishment of the zone of clear, single, binocular vision. The technique of the application of the various criteria such as

Sheard's, Percival's, Neumeuller's, and Morgan's are explained. Several lessons are devoted to analysis of the prescription in terms of various findings. The relationship to orthoptic procedures is covered and finally space is given to the analysis of cases taken from the optometrist's own files.

The course has been prepared by Dr. Charles Abel, Director of the Refracting Clinic at the Los Angeles College of Optometry and edited by Dr. Henry W. Hofstetter, Director, Division of Optometry at Indiana University.

The first lesson will be mailed to the subscriber upon receipt of the full payment of $50.00. Each subsequent lesson will be mailed to the subscriber upon his return of the previous lesson completed. A maximum of two years will be permitted to complete the course. Certificates of completion will be granted to those completing the course. Applications should be sent to Dean Henry A. Knoll, Los Angeles College of Optometry, 950 West Jefferson Boulevard, Los Angeles 7, California.

DEDICATE NEW BUILDING AT CHICAGO COLLEGE

Last summer I announced the start of the new building for Chicago College of Optometry. Being somewhat naive about these things I thought the approving of preliminary plans and engaging an architect would mean getting the structure under way. To my surprise I found that it really does not work out that way. It seems that all the detailed drawings had to be made; a contract and many sub-contracts had to be let; the Board had to have several meetings; and a large amount of money had to be made available and liquid, before the ground breaking took place. During January the construction work was actually started. On January 29 a ceremony took place in Chicago on the Illinois Tech campus with the A.O.A. President, Chicago College and Illinois Tech officials and the officers of the Illinois Optometric Association present. The new optometry building will be a fine two-story school building, similar in appearance to the buildings now on the campus of the Illinois Institute of Technology. It is planned that the new building will be ready for the fall 1954 semester of Chicago College of Optometry.

BACK ISSUES FOR UNIVERSITY OF HOUSTON

The College of Optometry, University of Houston, is in need of the following back issues of the AMERICAN JOURNAL OF OPTOMETRY to complete their sets of annual volumes of this magazine and to permit their holdings of our issues to be bound, for permanent use by students and faculty.

Optometrists able to supply one or more of the following monthly issues are urged to write or send same direct to Dr. Charles R. Stewart, Dean, College of Optometry, University of Houston, Cullen Boulevard, Houston 4, Texas.

MISSING MONTHLY ISSUES*

Volume Number	Year	
1	1924	All twelve issues, January through December.
2	1925	All twelve issues, January through December.
3	1926	All twelve issues, January through December.
4	1927	All twelve issues, January through December.
18	1941	All twelve issues, January through December.
19	1942	All twelve issues, January through December.
20	1943	All twelve issues, January through December.
21	1944	All twelve issues, January through December.
23	1946	April issue only.

*The Journal office is unable to supply the above monthly issues.

CHAIRMAN EMERITUS N.I.C.E:C. DIES AT ROCHESTER

January 30, Avery DeH. Prangen, M.D., 63, died at the St. Mary's Hospital, Rochester, Minnesota. For several years he had been suffering from a coronary, which during the last year or so caused his partial retirement from active practice. Dr. Prangen was chief of the department of ophthalmology at the Mayo Clinic at the time of his death. He was widely known in ophthalmology for his studies in refraction and ocular motility. Optometrists knew him best as the first chairman and organizer of the National Interprofessional Committee on Eye Care. Dr. Prangen served his profession with great distinction and he will be missed, indeed, in both ophthalmology and optometry.

NEWS BRIEFS

The Massachusetts College of Optometry will be host to the New England Occupational Vision Seminar. The meeting will be on the college campus at Boston, February 21 and 22. The speakers will be Dr. H. C. Kline, New Haven: Dr. E. N. Pierce, Attleboro: R. M. Bixler, New Haven: Wm. Cammeron, Southbridge: R. A. Sherman, Rochester: L. S. Cooke, and R. Clair of Boston. . . . Dr. T. R. Murroughs, associate professor of psychology, Northern Illinois College of Optometry, has been granted a leave of absence to continue his studies at Loyola University, Chicago. . . . Martha S. Stem, former executive secretary of the A.O.A. Department of Public Information, is now director of public relations for the O.E.P. at Duncan, Oklahoma. . . . Pennsylvania State College of Optometry has installed three refracting rooms and a pathology service at the Riverview Home for

the aged and infirm in Philadelphia. This new free clinic is made possible by the city administration, and will be staffed by the faculty and senior students of the college. . . . An Occupational Vision Seminar will take place May 18, Kellogg Center, Michigan State College, East Lansing, Michigan. . . . A three-day Forum on Vision Problems in Schools was sponsored by the A.O.A. Committee on School Vision and the Northeastern Ohio Chapter of the American Academy of Optometry in Cleveland, February 12, 13 and 14. Dr. Lois B. Bing, Cleveland, was chairman. . . . June—always a fine month for vacations—presents two outstanding events to attract optometrists—the first, the Optical Fair, Palmer House, Chicago, June 5-10, and the second—the annual Congress of the A.O.A., Hotel Olympia, Seattle, Washington, June 20-23. Now is the time to plan your vacation to include one or both of these fine events. . . . Dr. Richard Feinberg, president, Northern Illinois College of Optometry, was the commencement speaker at the January 22 graduation exercises of Chicago College of Optometry in Chicago. . . . Dr. Joseph Tiffin, professor of psychology, Purdue University, was the commencement speaker at the January 24 graduation exercises of Northern Illinois College of Optometry in Chicago. . . . The Invisible Contact Lens Service, Chicago, has been cited before the Federal Trade Commission on a complaint charging false and misleading advertising. The hearing on this complaint is set for February 24 in Chicago. . . . Mr. M. H. Stanley of the Univis Lens Company was elected president of the Optical Manufacturers Association at its annual meeting in New York City January 21. Mr. E. H. Titmus of the Titmus Optical Company was elected vice-president of the association. . . . The Better Vision Institute has set aside $18,000 for a study of conditions adversely upsetting ophthalmic optics—this is the start of a comprehensive program to correct some of the conditions affecting the visual well-being of millions of Americans. . . . Dr. Charles Sheard has now finished his editorial work on the copy for the *Sheard Commemorative Volume*. The Journal editorial staff are now working on the manuscript which will go to the publishers in a few weeks. . . . Dr. N. C. Kephart of Purdue, Dr. Leo Manas of Chicago College of Optometry, and Dr. Daniel Woolf of the School of Optometry, Columbia University, were the speakers at the Mid-Winter Congress of the Optometrical Association of Ontario, at Windsor, in January.

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WE THANK THE JOURNAL FOR CONTRIBUTING THIS SPACE—1954 OPTICAL FAIR COMMITTEE

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